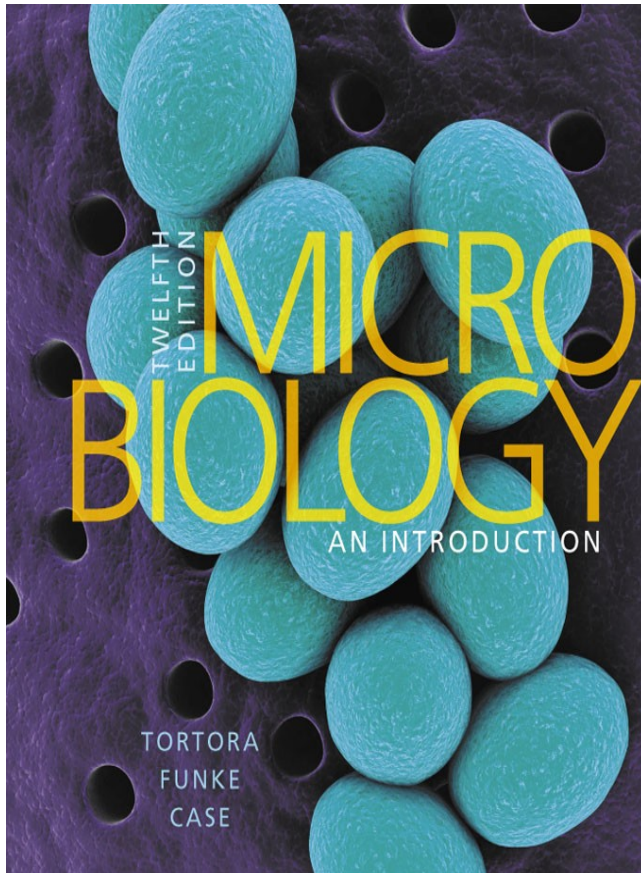


Microbiology an Introduction

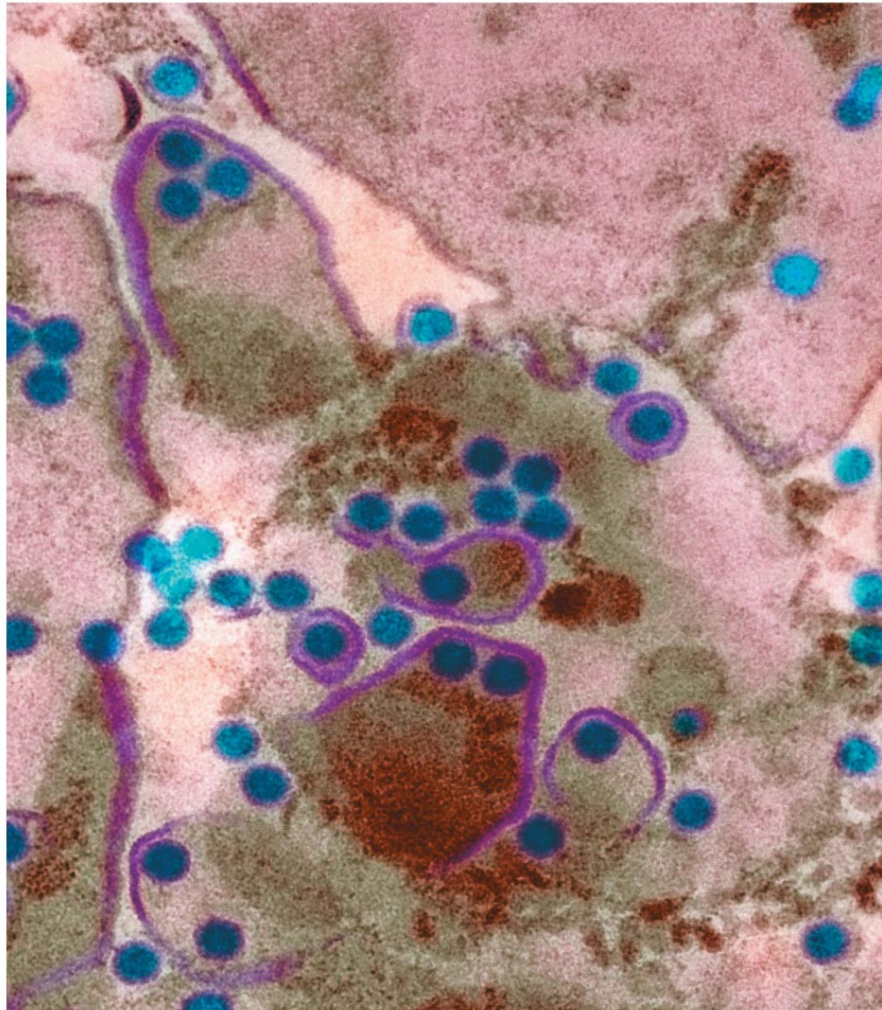
Twelfth Edition



Chapter 23

Microbial Diseases of the Cardiovascular and Lymphatic Systems

Dengue Virus (Blue) Cells



Structure and Function of the Cardiovascular and Lymphatic Systems (1 of 3)

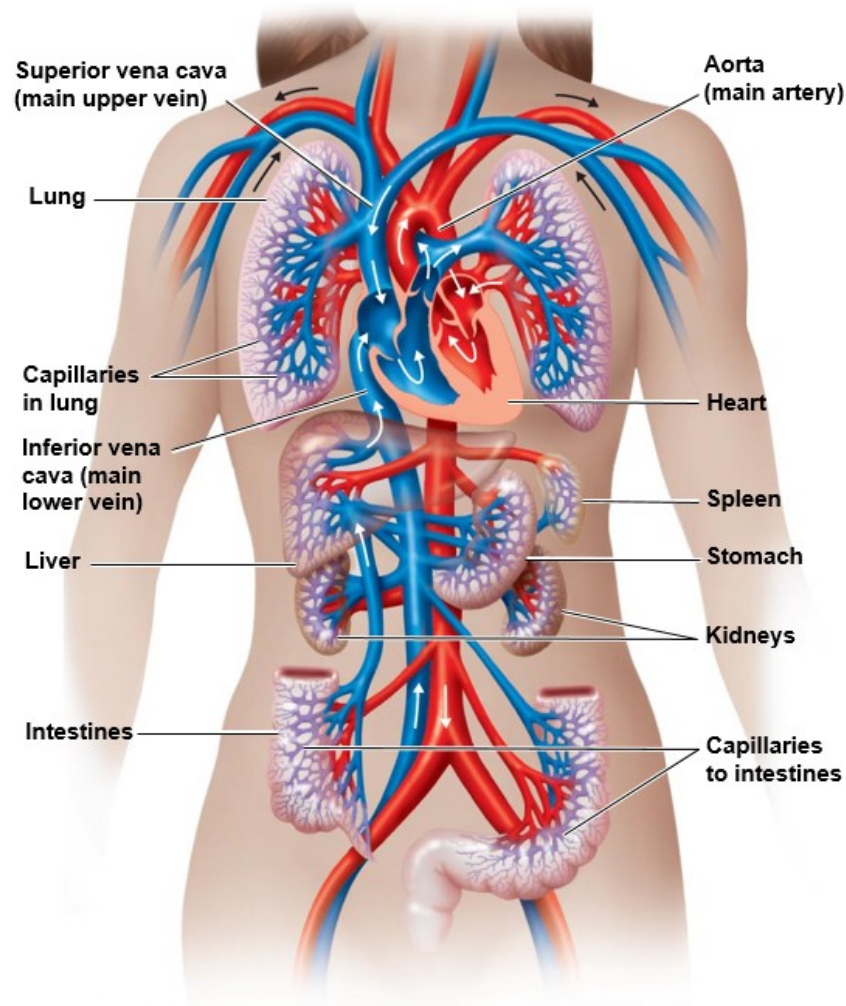
Learning Objective

23-1 Identify the role of the cardiovascular and lymphatic systems in spreading and eliminating infections.

Structure and Function of the Cardiovascular and Lymphatic Systems (2 of 3)

- **Cardiovascular system:** circulates blood through the body's tissues
 - Includes the heart and associated arteries, veins, and capillaries
 - Delivers substances to and removes substances from the cells

Figure 25.1 The Human Cardiovascular System and Related Structures

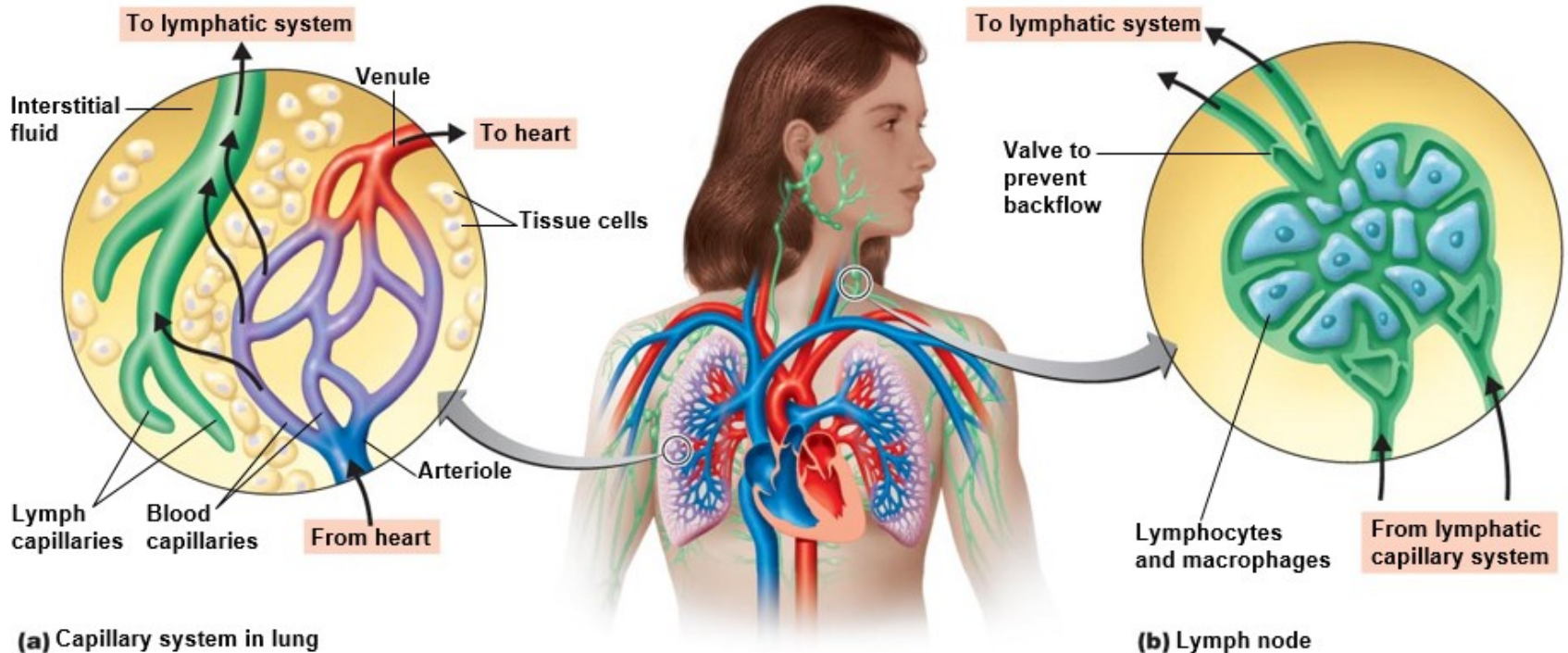


Structure and Function of the Cardiovascular and Lymphatic Systems (3 of 3)

- **Lymphatic system**

- Plasma leaves blood capillaries to become interstitial fluid
- Lymph capillaries transport interstitial fluid (lymph) to lymph vessels (lymphatics) and lymph nodes
 - Picks up microorganisms and infectious agents
- Lymph nodes contain fixed macrophages, B cells, and T cells
 - **Buboes:** swollen lymph nodes

Figure 23.2 The Relationship Between the Cardiovascular and Lymphatic Systems



Check Your Understanding-1

Check Your Understanding

- ✓ Why is the lymphatic system so valuable for the working of the immune system?
23-1

Bacterial Diseases of the Cardiovascular and Lymphatic Systems (1 of 3)

Learning Objectives

23-2 List the signs and symptoms of sepsis, and explain the importance of infections that develop into septic shock.

23-3 Differentiate gram-negative sepsis, gram-positive sepsis, and puerperal sepsis.

23-4 Describe the epidemiologies of endocarditis and rheumatic fever.

23-5 Discuss the epidemiology of tularemia.

Bacterial Diseases of the Cardiovascular and Lymphatic Systems (2 of 3)

Learning Objectives

23-6 Discuss the epidemiology of brucellosis.

23-7 Discuss the epidemiology of anthrax.

23-8 Discuss the epidemiology of gas gangrene.

23-9 List three pathogens that are transmitted by animal bites and scratches.

Bacterial Diseases of the Cardiovascular and Lymphatic Systems (3 of 3)

Learning Objectives

23-10 Compare and contrast the causative agents, vectors, reservoirs, symptoms, treatments, and preventive measures for plague, Lyme disease, and Rocky Mountain spotted fever.

23-11 Identify the vector, etiology, and symptoms of five diseases transmitted by ticks.

23-12 Describe the epidemiologies of epidemic typhus, endemic murine typhus, and spotted fevers.

Sepsis and Septic Shock

- **Septicemia**

- Acute illness due to the presence of pathogens or their toxins in the blood

- **Sepsis**

- Systemic inflammatory response syndrome (SIRS)

- **Lymphangitis**

- Inflamed lymph vessels

- **Severe sepsis**

- Decreased blood pressure and dysfunction of at least one organ

- **Septic shock**

Figure 23.3 Lymphangitis, One Sign of Sepsis



Gram-Negative Sepsis (1 of 2)

- Also called endotoxin shock
- Endotoxins (lipopolysaccharides [LPS]) cause a severe drop in blood pressure
- Antibiotics can worsen the condition by killing bacteria
- Treatment involves neutralizing the LPS components and inflammatory-causing cytokines

Gram-Negative Sepsis (2 of 2)

- Potent exotoxins that cause toxic shock syndrome
- Hospital-acquired infections
 - **Enterococcus faecium** and **Enterococcus faecalis**
 - Inhabit the colon
 - Colonize wounds and the urinary tract
 - Resistant to many antibiotics
 - **Group B streptococci (GBS)**
 - **Streptococcus agalactiae**
 - Neonatal sepsis

Puerperal Sepsis

- Also called **puerperal fever** and **childbirth fever**
 - Caused by **Streptococcus pyogenes**
 - Transmitted to the mother during childbirth
 - Infects the uterus and progresses to an infection of the abdominal cavity (peritonitis)

Check Your Understanding-2

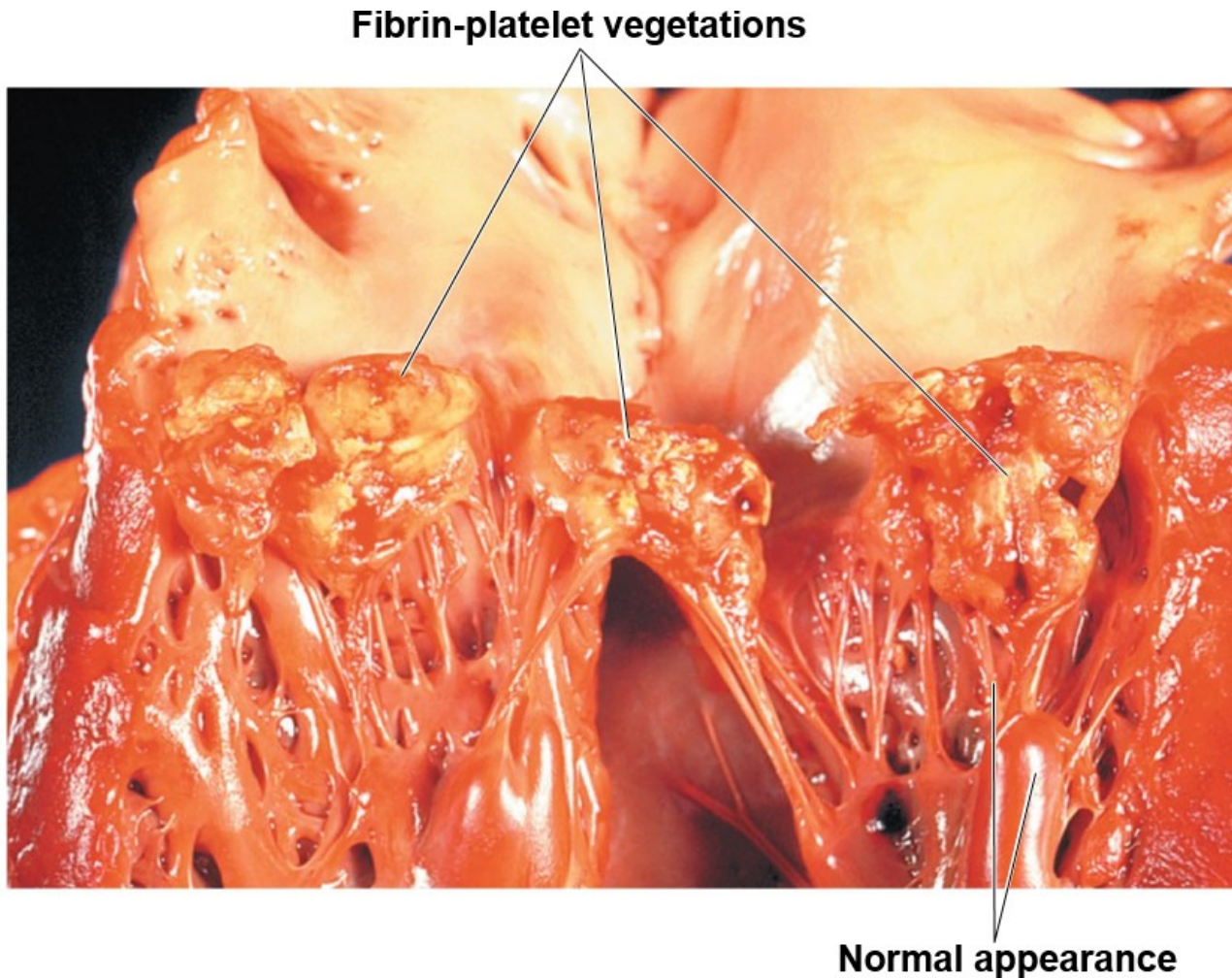
Check Your Understanding

- ✓ What are two of the conditions that define the systemic inflammatory response syndrome of sepsis?
23-2
- ✓ Are the endotoxins that cause sepsis from gram-positive or gram-negative bacteria?
23-3

Bacterial Infections of the Heart

- **Endocarditis**
 - Inflammation of the endocardium
- **Subacute bacterial endocarditis**
 - Impairs the function of the heart valves
 - Alpha-hemolytic streptococci from an oral or tonsil infection
- **Acute bacterial endocarditis**
 - Caused by **Staphylococcus aureus**
- **Pericarditis**
 - Inflammation of the sac around the heart
 - Streptococci

Figure 23.4 Bacterial Endocarditis



Check Your Understanding-3

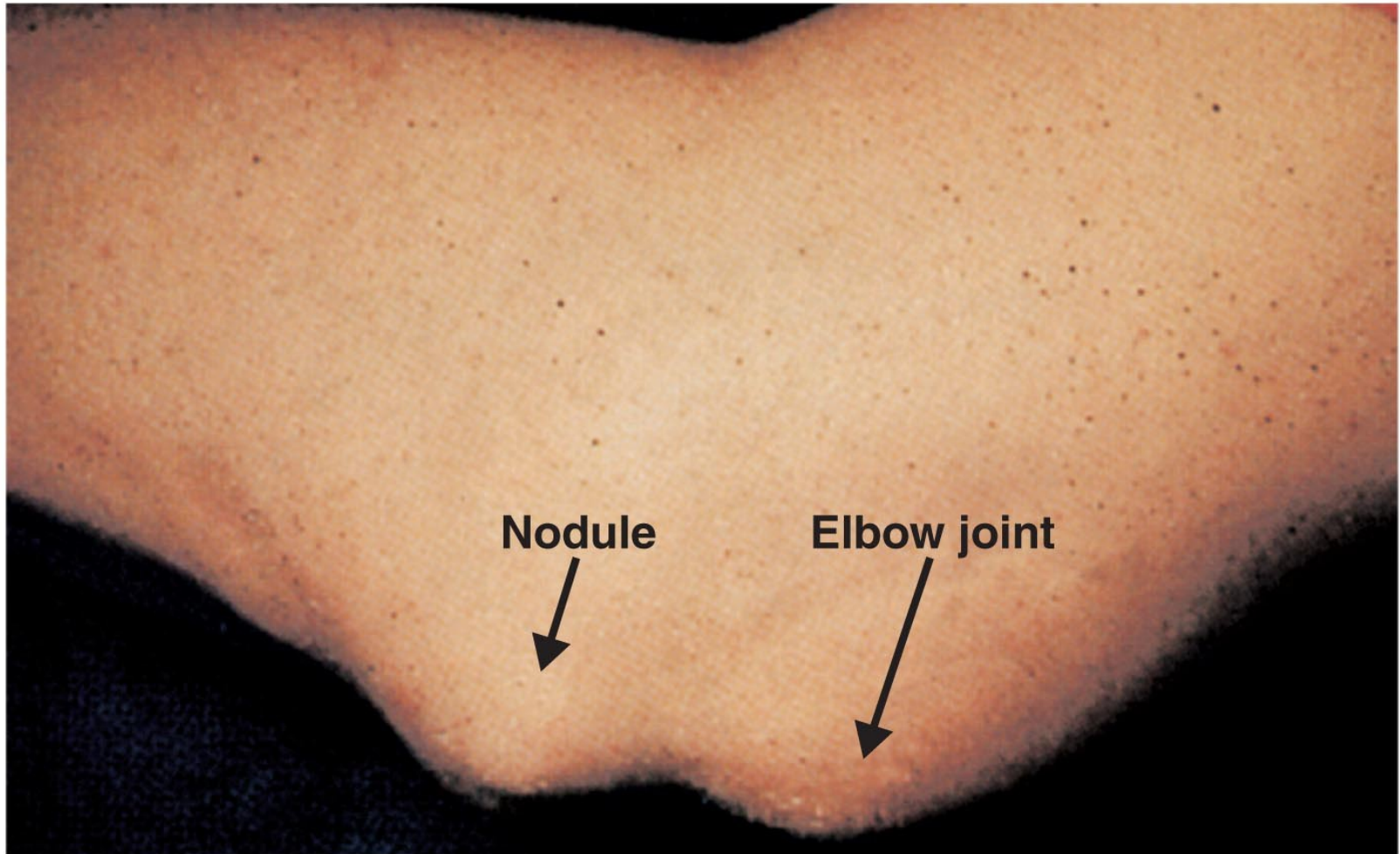
Check Your Understanding

- ✓ What medical procedures are usually the cause of endocarditis?
23-4

Rheumatic Fever

- Autoimmune complication of **S. pyogenes** infections
- Inflammation of the heart valves
 - Immune reaction against streptococcal M protein
- Subcutaneous nodules at the joints
- **Sydenham's chorea**
 - Purposeless, involuntary movements

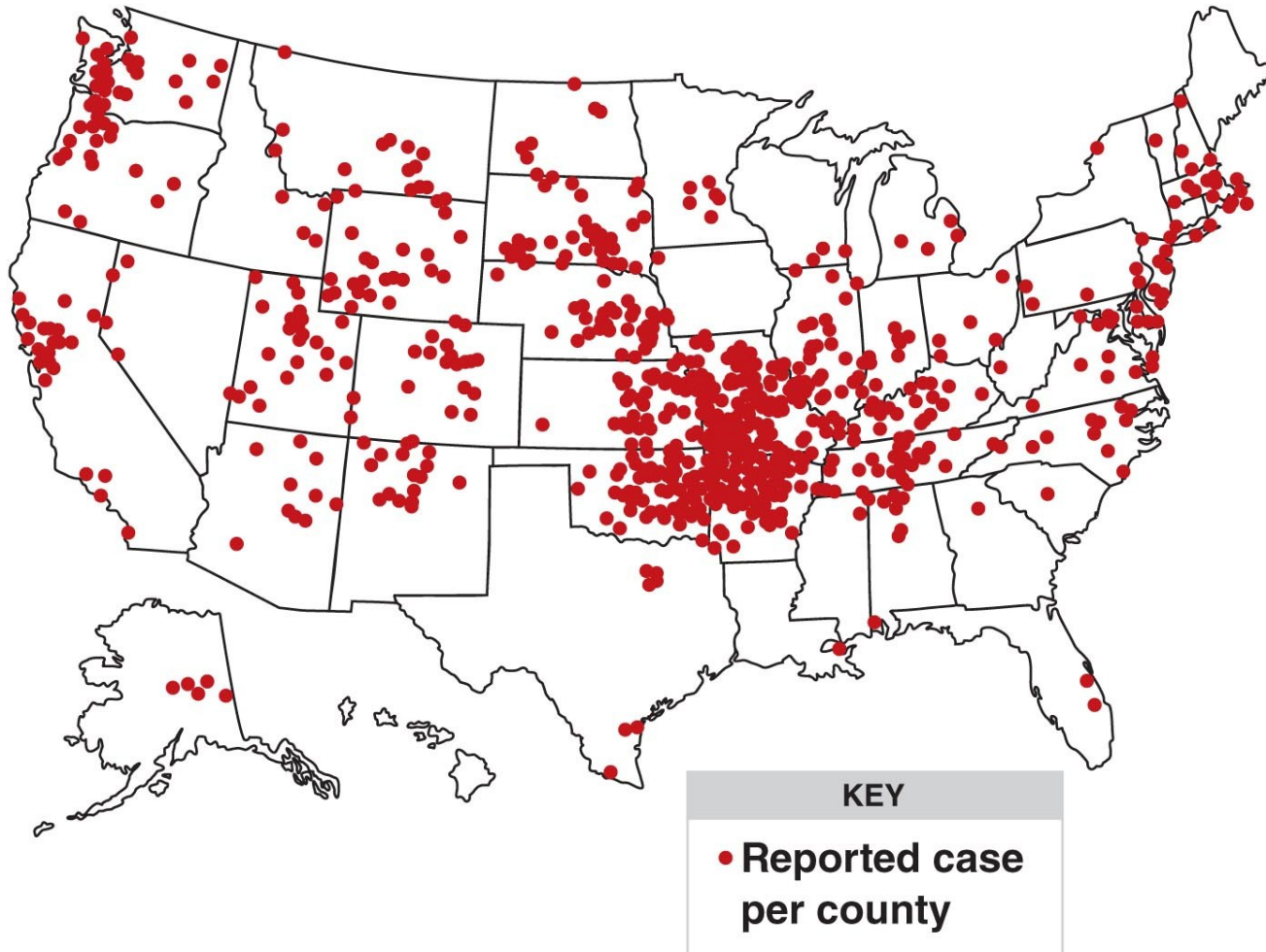
Figure 23.5 A Nodule Caused by Rheumatic Fever



Tularemia

- Caused by **Francisella tularensis**
 - Gram-negative rod
- Zoonotic disease
- Transmitted from rabbits, ticks, and insects by deer flies
- Creates an ulcer at the site of entry
- Bacteria reproduce in phagocytes
 - Enlarges the regional lymph nodes
- Mortality usually < 30%

Figure 23.6 Tularemia cases in the United States (2001-2010)



Check Your Understanding-4

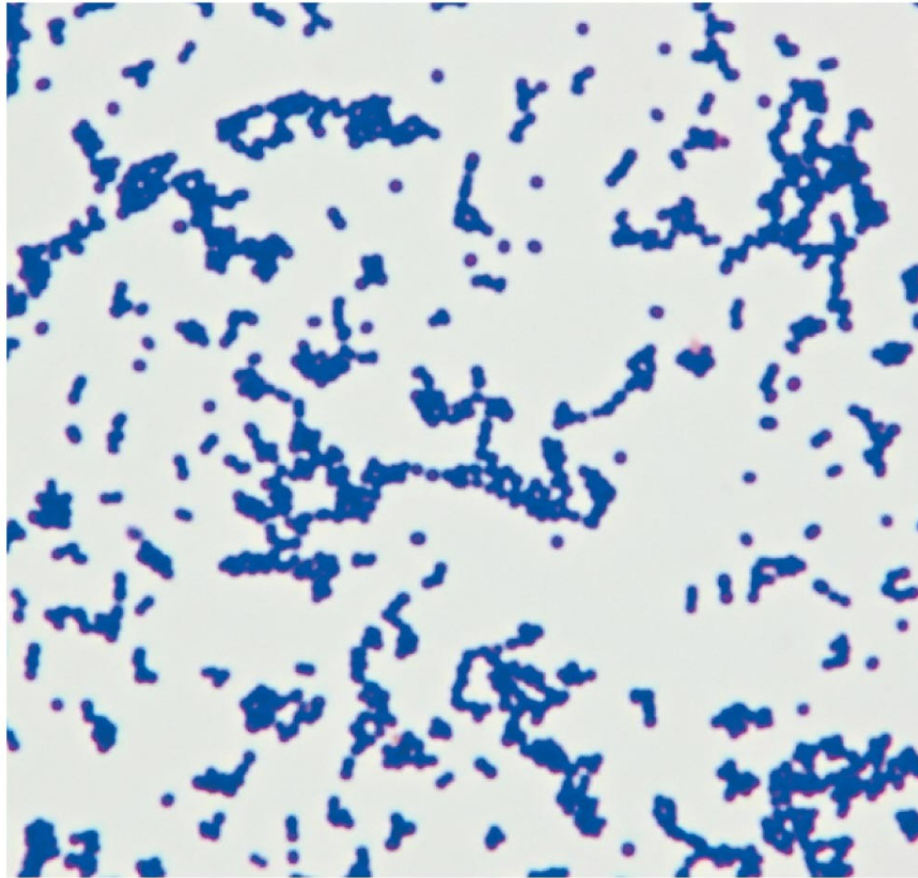
Check Your Understanding

- ✓ What animals are the most common reservoir for tularemia?
23-5

Diseases in Focus: Infections from Human Reservoirs

- A 27-year-old woman has a fever and cough for 5 days. She is hospitalized when her blood pressure drops. Despite aggressive treatment with fluids and massive doses of antibiotics, she dies 5 hours after hospitalization. Catalase-negative, gram-positive cocci are isolated from her blood.
- What infections could cause these symptoms?

Diseases in Focus 23.1 (1 of 3)



LM

5 μ m

Diseases in Focus 23.1 (2 of 3)

Disease	Pathogen	Symptoms	Reservoir	Method of Transmission	Treatment
BACTERIAL DISEASES					
Septic Shock	Gram-negative bacteria, enterococci, group B Streptococci	Fever, chills, increased heart rate; lymphangitis	Human body	Injection; catheterization	Antibiotics
Puerperal Sepsis	Streptococcus pyogenes	Peritonitis; sepsis	Human nasopharynx	Nosocomial	Penicillin
Endocarditis Subacute Bacterial Acute Bacterial	Mostly alpha-hemolytic streptococci; Staphylococcus aureus	Fever, general weakness, heart murmur; damage to heart valves	Human nasopharynx	From focal infection	Antibiotics
Pericarditis	Streptococcus pyogenes	Fever; general weakness; heart murmur	Human nasopharynx	From focal infection	Antibiotics
Rheumatic Fever	Group A beta-hemolytic streptococci	Arthritis, fever; damage to heart valves	Immune reactions to streptococcal infections	Not transmissible	Supportive. Prevention: penicillin to treat streptococcal sore throats

Diseases in Focus 23.1 (3 of 3)

Disease	Pathogen	Symptoms	Reservoir	Method of Transmission	Treatment
VIRAL DISEASES					
Burkitt's Lymphoma	Epstein-Barr (EB) virus	Tumor	Unknown	Unknown	Surgery
Infectious Mononucleosis	EB virus	Fever, general weakness	Humans	Saliva	None
Cytomegalovirus	Cytomegalovirus	Mostly asymptomatic; initial infection acquired during pregnancy can be damaging to fetus	Humans	Body fluids	Ganciclovir, fomivirsen
UNKNOWN ETIOLOGY					
Kawasaki Syndrome	Unknown	Fever, rash, coronary artery abnormalities	Unknown	Unknown	None

Brucellosis (Undulant Fever)

- **Brucella** spp.
 - Aerobic gram-negative rods
 - **Brucella abortus** (elk, bison, cows)
 - **Brucella suis** (swine)
 - **Brucella melitensis** (goats, sheep, camels)
- Transmitted via milk from infected animals or contact with infected animals
- Persists in the reticuloendothelial system; evades phagocytes
- Undulant fever (malaise, night sweats, muscle aches)

Check Your Understanding-5

Check Your Understanding

- ✓ What ethnic group in the United States is most commonly affected by brucellosis, and why?
23-6

Anthrax (1 of 3)

- Caused by **Bacillus anthracis**
 - Gram-positive, endospore-forming aerobic rod
- Found in soil
- Primarily affects grazing animals
- Spores introduced into the body are taken up by macrophages and germinate
 - Bacteria enter the bloodstream and release toxins
- Treated with ciprofloxacin or doxycycline

Vaccination of livestock

Anthrax (2 of 3)

- Bacteria produces virulence factors
 - Protective antigen: binds the toxins to target cells, permitting their entry
 - Edema toxin: causes local swelling and interferes with phagocytosis
 - Lethal toxin: targets and kills macrophages
 - Amino acid capsule that avoids an immune response

Anthrax (3 of 3)

- **Cutaneous anthrax**
 - Endospores enter through a minor cut
 - 20% mortality rate without treatment
- **Gastrointestinal anthrax**
 - Ingestion of undercooked, contaminated food
 - 50% mortality rate
- **Inhalational (pulmonary) anthrax**
 - Inhalation of endospores
 - Bacteria enter the bloodstream; progresses into septic shock
 - Near 100% mortality rate

Figure 23.7 Anthrax Lesion



Check Your Understanding-6

Check Your Understanding

- ✓ How do animals such as cattle become victims of anthrax?
23-7

Applications of Microbiology: Protection against Bioterrorism

- 1346: plague-ridden bodies used by the Tartar army against Kaffa (Ukraine)
- 1937–1945: plague-carrying flea bombs used in the Sino-Japanese War
- 1979: explosion of **B. anthracis** weapons plant in the Soviet Union
- 1984: **Salmonella enterica** used against the people of The Dalles, Oregon
- 1996: **Shigella dysenteriae** used to contaminate food
- 2001: **B. anthracis** distributed in the United States

Applications of Microbiology

23.2

Bacteria	Viruses
Bacillus anthracis	Arenaviruses
Brucella spp.	Hantavirus, encephalitis viruses
Chlamydophila psittaci	Hemorrhagic fever viruses (Ebola, Marburg, Lassa)
Clostridium botulinum toxin	Monkeypox
Coxiella burnetii	Nipah virus
Francisella tularensis	Smallpox
Rickettsia prowazekii	
Shigella spp.	
Vibrio cholerae	
Yersinia pestis	

Gangrene

- **Ischemia:** loss of blood supply to tissue
- **Necrosis:** death of tissue
- **Gangrene:** death of soft tissue
- **Gas gangrene**
 - Caused by **Clostridium perfringens**, a gram-positive, endospore-forming anaerobic rod
 - Grows in necrotic tissue
 - Produces toxins that move along muscle bundles
 - Treatment includes the surgical removal of necrotic tissue and/or use of a **hyperbaric chamber**

Figure 23.8 The Toes of a Patient with Gangrene



Check Your Understanding-7

Check Your Understanding

- ✓ Why are hyperbaric chambers effective in treating gas gangrene?
23-8

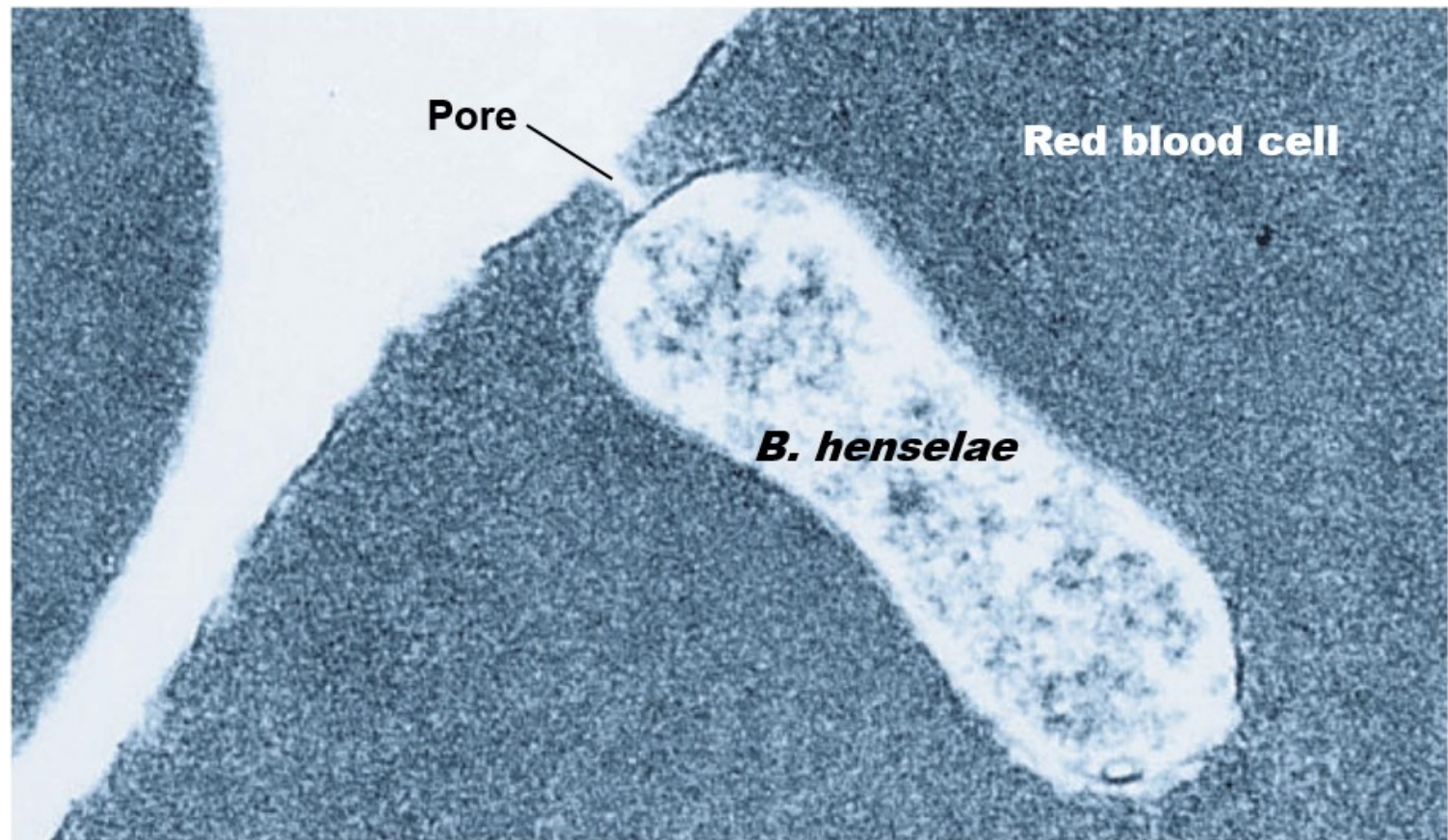
Systemic Diseases Caused by Bites and Scratches

- 1% of ER visits
- Dogs make up 80% of reported bites; cats about 10%
 - Cat bites have higher infection rates
- **Pasteurella multocida**
 - Gram-negative rod; causes sepsis
- **Staphylococcus, Streptococcus, Corynebacterium**

Cat-Scratch Disease

- Caused by **Bartonella henselae**
 - Aerobic, gram-negative
 - Inhabits cat RBCs; carried in the blood of 50% of cats
 - Multiplies in the digestive system of cat fleas
 - Cat claws contaminated with flea feces scratch human
- Forms a papule at the infection site and swollen lymph nodes
- Self-limiting

Figure 23.9 Electron Micrograph Showing the Location of Bartonella Henselae Within a Red Blood Cell.



TEM | 0.5 μm

Rat-Bite Fever

- Transmitted via rat bites
- Streptobacillary rat-bite fever
 - Found in North America
 - Caused by **Streptobacillus moniliformis**
 - Filamentous, gram-negative, pleomorphic, fastidious
 - Fever, chills, muscle pain; mortality rate of 10%
- Spirillar fever
 - Caused by **Spirillum minus**
 - Similar to streptobacillary rat-bite fever

Check Your Understanding-8

Check Your Understanding

- ✓ **Bartonella henselae**, the pathogen of cat-scratch disease, is capable of growth in what insect?
23-9

Diseases in Focus: Infections from Animal Reservoirs Transmitted by Direct Contact

- A 10-year-old girl is admitted to a local hospital after having fever (40°C) for twelve days and back pain for 8 days. Bacteria cannot be cultured from tissues. She has a recent history of dog and cat scratches. She recovers without treatment.
- What infections could cause these symptoms?

Diseases in Focus 23.2 (1 of 3)



Diseases in Focus 23.2 (2 of 3)

Disease	Pathogen	Symptoms	Reservoir	Method of Transmission	Treatment
BACTERIAL DISEASES					
Brucellosis	Brucella spp.	Local abscess; undulating fever	Grazing mammals	Direct contact	Tetracycline, streptomycin
Anthrax	Bacillus anthracis	Papule (cutaneous); bloody diarrhea (gastrointestinal); septic shock (inhalational)	Soil; large grazing mammals	Direct contact; ingestion; inhalation	Ciprofloxacin; doxycycline
Animal Bites	Pasteurella multocida	Local infection; sepsis	Animal mouths	Dog/cat bites	Penicillin
Rat-Bite Fever	Streptobacillus moniliformis, Spirillum minus	Sepsis	Rats	Rat bites	Penicillin
Cat-Scratch	Bartonella	Prolonged fever	Domestic	Cat bites or	Antibiotics

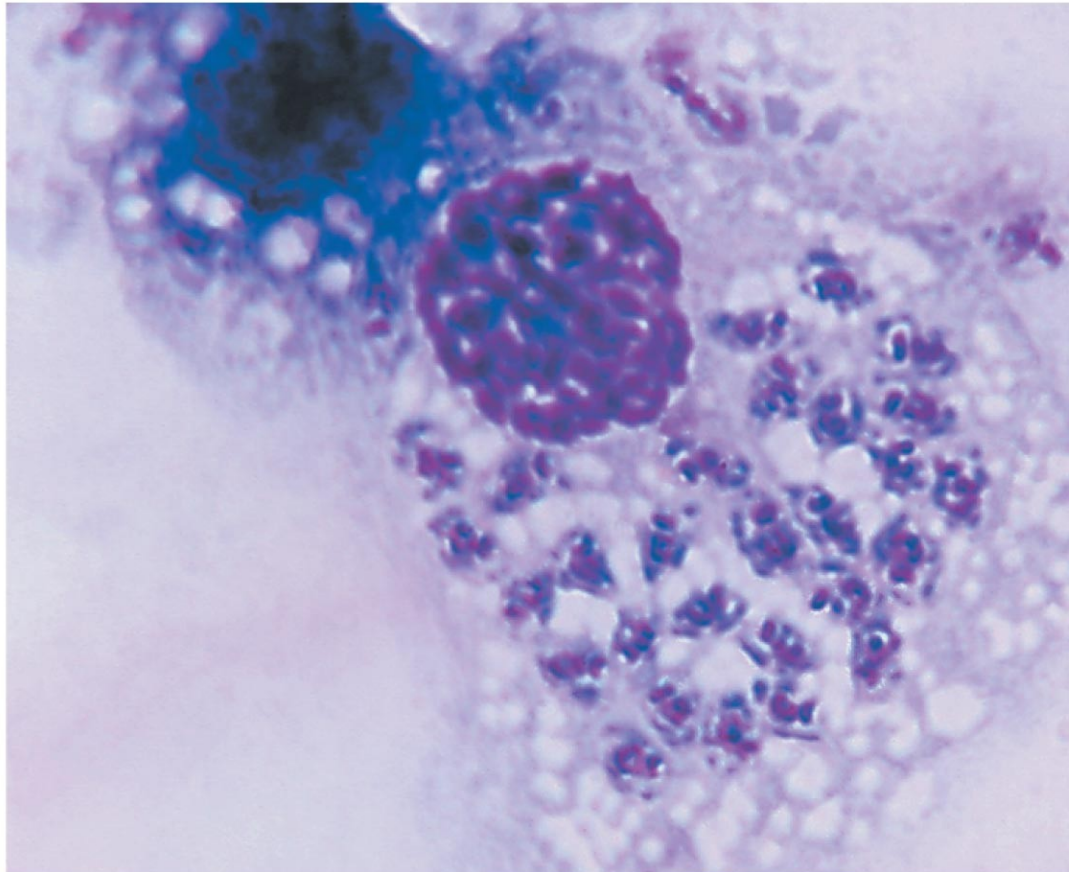
Diseases in Focus 23.2 (3 of 3)

PROTOZOA N DISEASE					
Toxoplasmosis	Toxoplasma gondii	Mild disease; initial infection acquired during pregnancy can be damaging to fetus; serious illness in AIDS patients	Domestic cats	Ingestion	Ingestion Pyrimethamine, sulfadiazine and folic acid

Diseases in Focus: Infections Transmitted by Vectors

- A 22-year-old soldier returning from a tour of duty in Iraq has three painless skin ulcers. She reports being bitten by insects every night. Ovoid, protozoa like bodies, are observed within her macrophages by examination with a light microscope.
- What infections could cause these symptoms?

Diseases in Focus 23.3 (1 of 3)



LM 5 μ m

Diseases in Focus 23.3 (2 of 3)

Disease	Pathogen	Symptoms	Reservoir	Method of Transmission	Treatment
BACTERIAL DISEASES					
Tularemia	Francisella tularensis	Local infection; pneumonia	Rabbits; ground squirrels	Direct contact with infected animals, deer fly bite; inhalation	Tetracycline
Plague	Yersinia pestis	Enlarged lymph nodes; septic shock	Rodents	Fleas; inhalation	Streptomycin; tetracycline
Relapsing Fever	Borrelia spp.	Series of fever peaks	Rodents	Soft ticks	Tetracycline
Lyme Disease	Borrelia burgdorferi	Bull's-eye rash; neurologic symptoms	Field mice	Ixodes ticks	Antibiotics
Ehrlichiosis and Anaplasmosis	Ehrlichia spp. Anaplasma spp.	Flulike	Deer	Ixodes ticks	Tetracycline
Typhus Fever	Rickettsia prowazekii	High fever, stupor, rash	Squirrels	Pediculus humanus corporis louse	Tetracycline; chloramphenicol
Endemic Murine Typhus	Rickettsia typhi	Fever; rash	Rodents	Xenopsylla cheopis flea	Tetracycline; chloramphenicol
Rocky Mountain Spotted Fever	Rickettsia	Macular rash; fever;	Ticks;	Dermacentor	Tetracycline

Diseases in Focus 23.3 (3 of 3)

Disease	Pathogen	Symptoms	Reservoir	Method of Transmission	Treatment
VIRAL DISEASE					
Chikungunya Fever	Chikungunya virus	Fever; joint pain	Humans	Aedes mosquito	Supportive
PROTOZOAN DISEASES					
Chagas' Disease (American Trypanosomiasis)	Trypanosoma cruzi	Damage to heart muscle or peristaltic movement of gastrointestinal tract	Rodents, opossums	Reduviid bug	Nifurtimox
Malaria	Plasmodium spp.	Fever and chills at intervals	Humans	Anopheles mosquito	Malarone, artemisinin
Leishmaniasis	Leishmania spp.	L. donovani: systemic disease; L. tropica: skin sores; L. braziliensis: disfiguring damage to mucous Membranes	Small mammals	Sandfly	Antimony compounds
Babesiosis	Babesia microti	Fever and chills at intervals	Rodents	Ixodes ticks	Atovaquone and azithromycin

Plague (1 of 2)

- Caused by **Yersinia pestis**
 - Gram-negative rod
 - Transmitted by the rat flea (**Xenopsylla cheopis**)
 - Endemic to rats, ground squirrels, and prairie dogs
- Bacteria blocks the flea's digestive tract
 - Flea bites the host and ingested blood is regurgitated into the host
- Bacteria enter the bloodstream and proliferate in the lymph tissue
 - Cause intense swellings called buboes

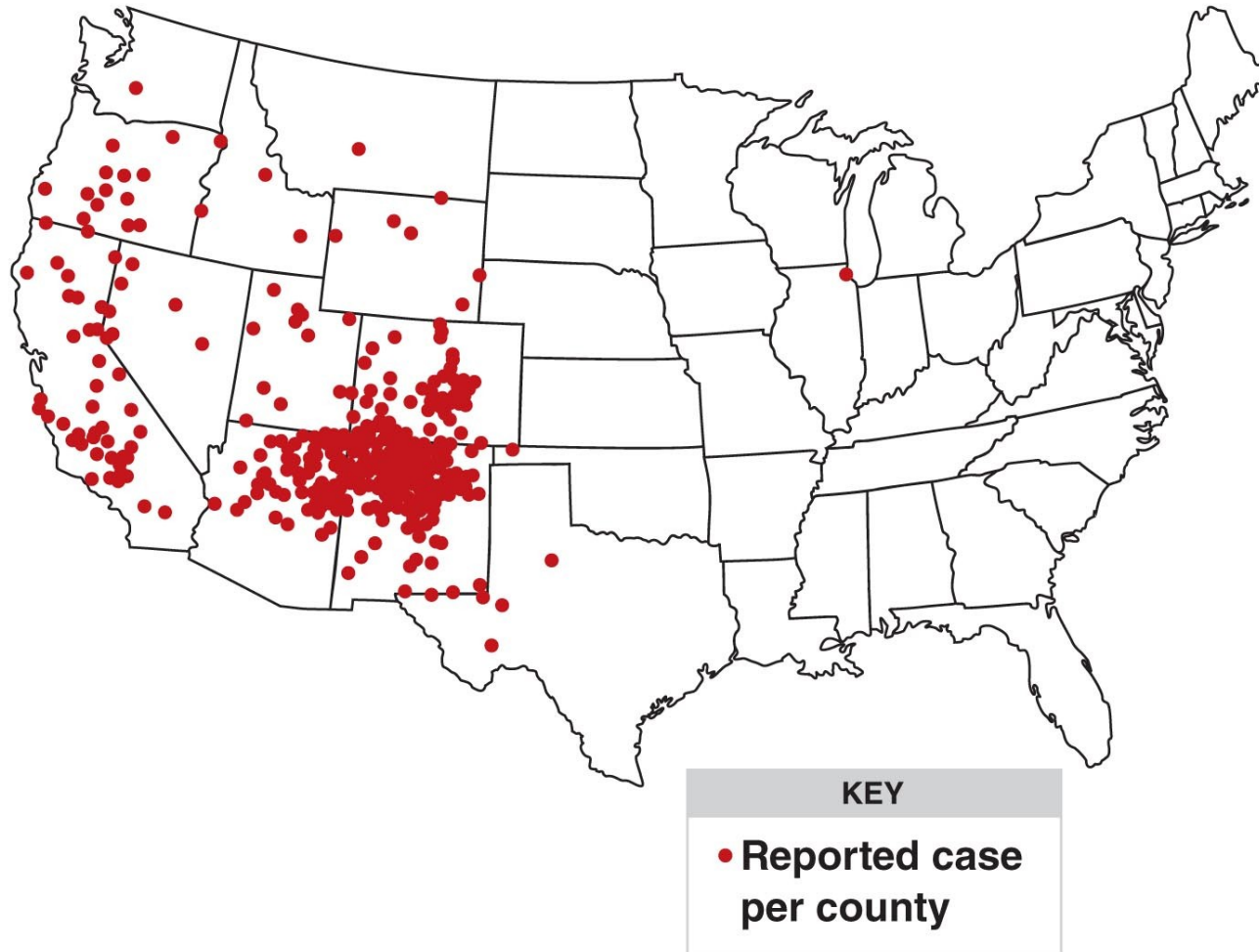
Plague (2 of 2)

- **Bubonic plague**
 - Bacterial growth in the blood and lymph
 - Most common form; 50–75% mortality rate
- **Septicemic plague**
 - Septic shock due to bacteria in the blood
- **Pneumonic plague**
 - Bacteria in the lungs
 - Easily spread by airborne droplets
 - Near 100% mortality rate
- Antibiotic prophylaxis for exposure

Figure 23.10 A Case of Bubonic Plague



Figure 23.11 The U.S. geographic distribution of human plague, 1970-2012



Relapsing Fever

- Caused by **Borrelia** spp.
 - Spirochete
- Transmitted by soft ticks that feed on rodents
- High fever, jaundice, rose-colored skin spots
- Successive relapses are less severe
- Treated with tetracycline

Lyme Disease (Lyme Borreliosis) (1 of 2)

- Caused by **Borrelia burgdorferi**
- Most common tickborne disease in the United States
- Field mice are the most common reservoir
 - Nymphal stage of the **Ixodes** tick feeds on mice and infects humans
- Ticks feed on deer, but are not infected
- Ticks must attach two to three days to transfer bacteria

Figure 23.12 Lyme Disease In the United States, Reported Cases by County, 2012

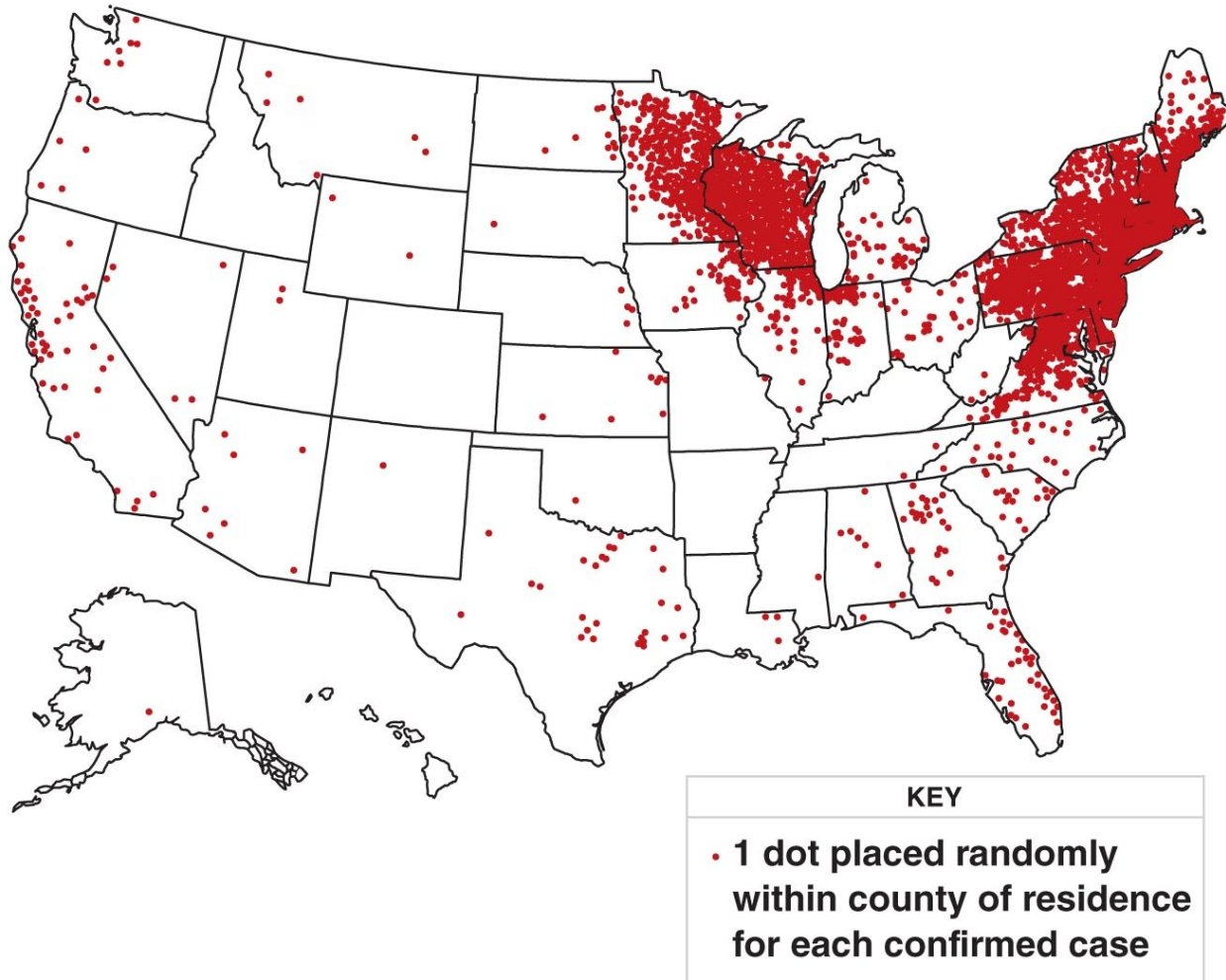
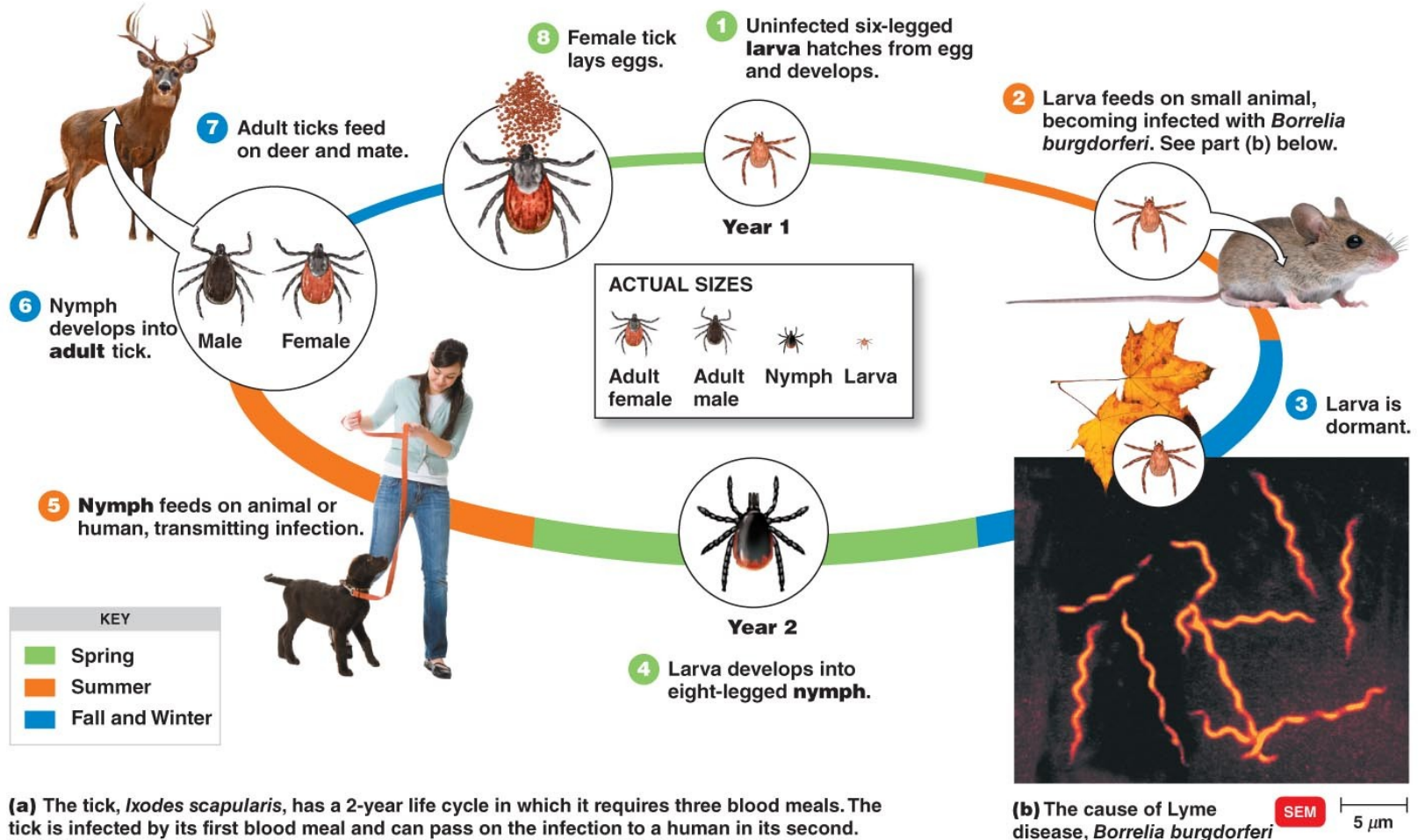


Figure 23.13 The Life Cycle of the Tick Vector of Lyme Disease



Lyme Disease (Lyme Borreliosis) (2 of 2)

- First phase
 - Bull's-eye rash; flulike symptoms
- Second phase
 - Irregular heartbeat; encephalitis; facial paralysis; memory loss
- Third phase
 - Arthritis due to an immune response
- Diagnosis via ELISA, indirect fluorescent-antibody (FA) test, or Western blot
- Treated with antibiotics
 - More difficult to treat in later stages

Figure 23.14 The Common Bull's-Eye Rash of Lyme Disease



Ehrlichiosis and Anaplasmosis

- **Human monocytotropic ehrlichiosis (HME)**
 - Caused by **Ehrlichia chaffeensis**
 - Gram-negative, rickettsia-like, obligately intracellular
 - Form aggregates (**morulae**) in monocytes
 - Vector is the Lone Star tick; reservoir is the white-tailed deer
- **Human granulocytic anaplasmosis (HGA)**
 - Caused by **Anaplasma phagocytophilum**
 - Vector is the **Ixodes** tick
- Both cause flulike disease
- Fatality less than 5%

Typhus (1 of 4)

- Caused by **Rickettsia** spp.
 - Obligate intracellular parasites
 - Infect the endothelial cells of the vascular system
 - Block and rupture the small blood vessels
 - Spread by arthropod vectors

Typhus (2 of 4)

- **Typhus fever** (epidemic louseborne typhus)
 - Caused by **Rickettsia prowazekii**
 - Carried by the body louse: **Pediculus humanus corporis**
 - Transmitted when louse feces are rubbed into the bite wound from the louse
 - Prolonged fever and a rash of red spots due to subcutaneous hemorrhaging
 - Treated with tetracycline and chloramphenicol

Typhus (3 of 4)

- **Endemic murine typhus**
 - Caused by **Rickettsia typhi**
 - Transmitted by the rat flea: **X. cheopis**
 - Rodents (**murine** = mouse) are common hosts
 - Mortality rate less than 5%
 - Clinically indistinguishable from typhus fever
 - Treated with tetracycline and chloramphenicol

Typhus (4 of 4)

- **Rocky Mountain spotted fever** (tickborne typhus)
 - Caused by **Rickettsia rickettsii**
 - Spread by wood ticks (**Dermacentor andersoni**) and dog ticks (**Dermacentor variabilis**)
 - Measles-like rash, except that the rash also appears on the palms and soles
 - Without early diagnosis, mortality rate is approximately 20%
 - Treatment with tetracycline and chloramphenicol

Figure 23.15 The U.S. Geographic Distribution of Rocky Mountain Spotted Fever (Tickborne Typhus), 2011

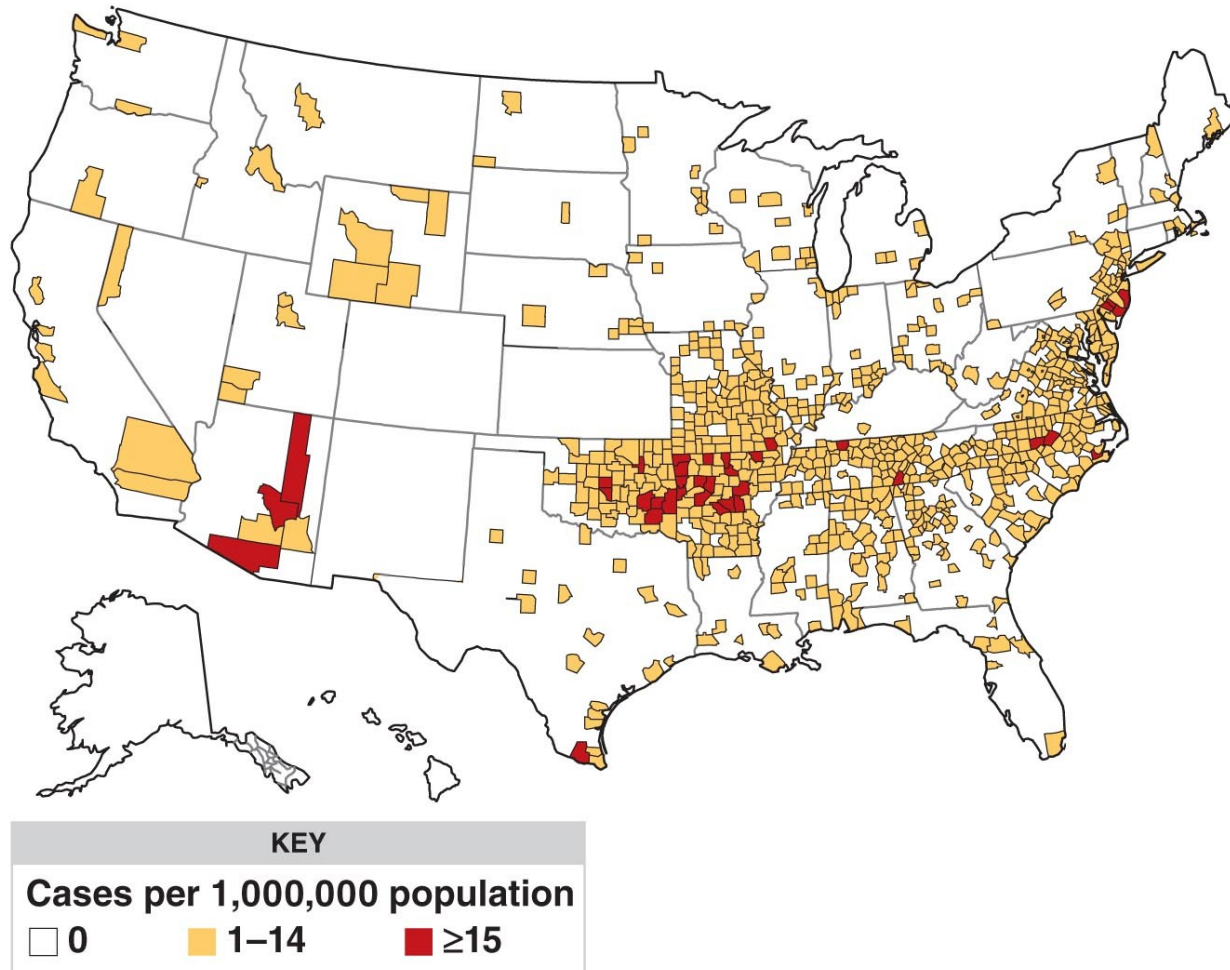


Figure 23.16 The Life Cycle of the Tick Vector (*Dermacentor* Spp.) of Rocky Mountain Spotted Fever

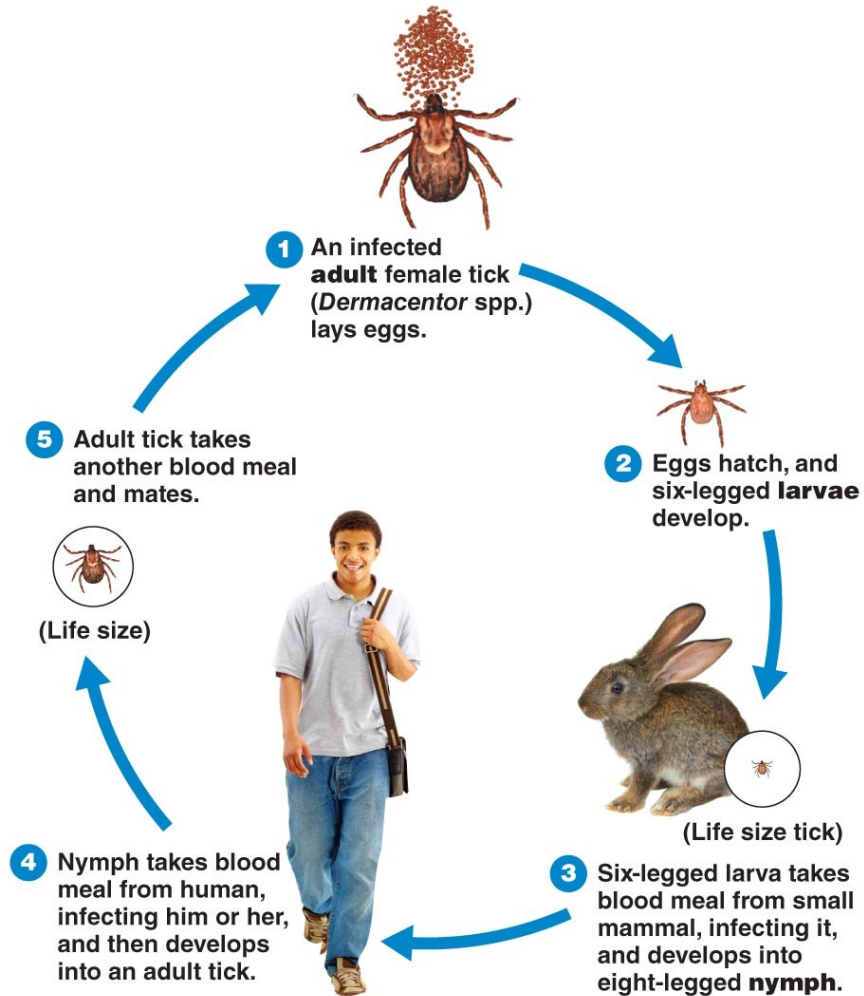


Figure 25.17 The Rash Caused by Rocky Mountain Spotted Fever



Check Your Understanding-9

Check Your Understanding

- ✓ Why is the plague-infected flea so eager to feed on a mammal?
23-10
- ✓ What animal does the infecting tick feed on just before it transmits Lyme disease to a human?
23-11
- ✓ Which disease is tickborne: epidemic typhus, endemic murine typhus, or Rocky Mountain spotted fever?
23-12

Viral Diseases of the Cardiovascular and Lymphatic Systems

Learning Objectives

23-13 Describe the epidemiologies of Burkitt's lymphoma, infectious mononucleosis, and CMV inclusion disease.

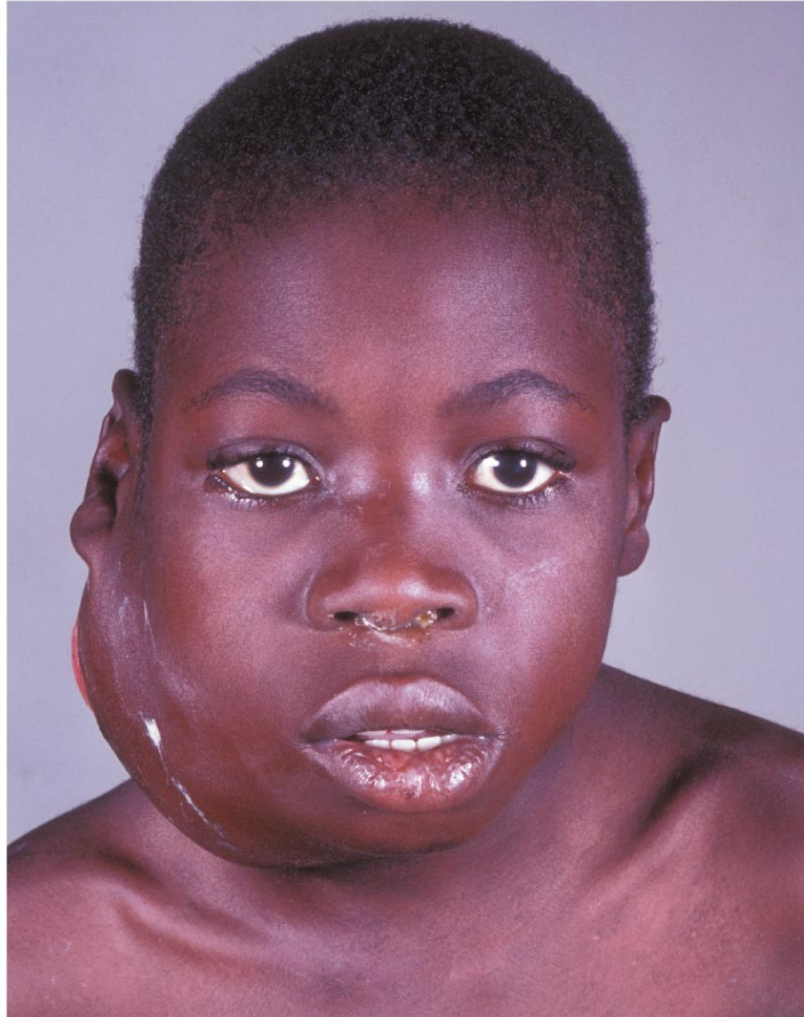
23-14 Compare and contrast the causative agents, vectors, reservoirs, and symptoms of yellow fever, dengue, dengue hemorrhagic fever, and chikungunya fever.

23-15 Compare and contrast the causative agents, reservoirs, and symptoms of Ebola hemorrhagic fever and **Hantavirus** pulmonary syndrome.

Burkitt's Lymphoma

- Tumor the of jaw; most common childhood cancer in Africa
 - Due to Epstein-Barr virus (human herpesvirus 4)
- Malaria suppresses the immune system response to the virus

Figure 23.18 A Child with Burkitt's Lymphoma



Check Your Understanding-10

Check Your Understanding

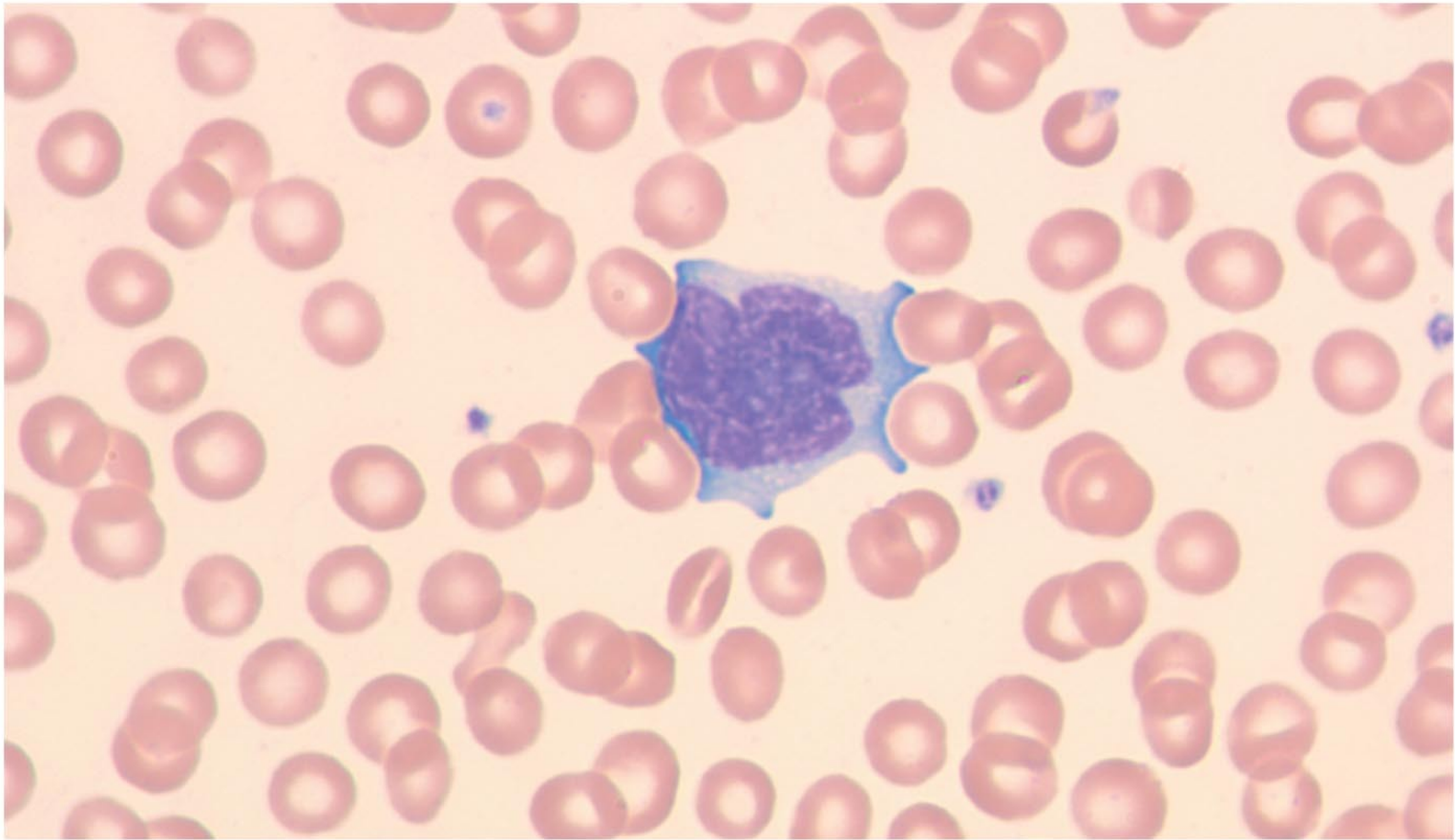
- ✓ Although not a disease with an insect vector, why is Burkitt's lymphoma most commonly a disease found in malarial areas?

23-13

Infectious Mononucleosis

- Caused by Epstein-Barr virus
- Childhood infections are often asymptomatic
- Transmitted via saliva; incubation of 4 to 7 weeks
- Fever, sore throat, swollen lymph nodes, enlarged spleen
- Replicates in resting memory B cells
 - Form unusual lobed nuclei
 - Produce heterophile antibodies
 - Weak and multispecific

Figure 23.20 A Lymphocyte with the Unusual Lobed Nucleus That Is Characteristic of Mononucleosis



LM

10 μm

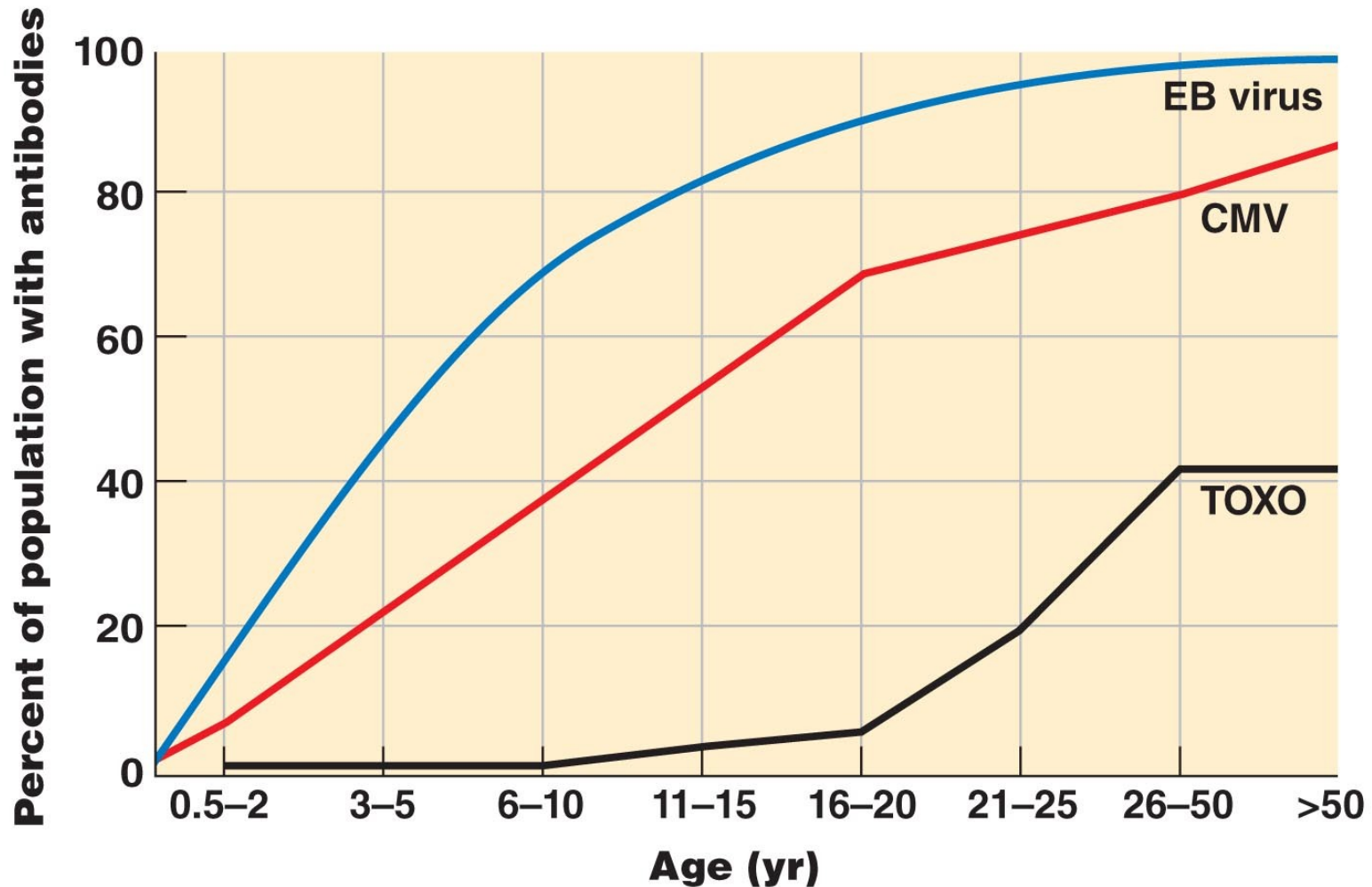
Other Diseases and Epstein-Barr Virus

- Epstein-Barr virus associated with:
 - **Multiple sclerosis**
 - Autoimmune attack on the nervous system
 - **Hodgkin's lymphoma**
 - Tumors of the spleen, lymph nodes, and liver
 - **Nasopharyngeal cancer**

Cytomegalovirus Infections

- Cytomegalovirus (human herpesvirus 5)
- Remains latent in white blood cells
- Infected cells swell
 - Form "owl's eyes" inclusions
- May be asymptomatic or mild in adults
- Cytomegalic inclusion disease (CID)
 - Transmitted across the placenta; causes mental retardation or hearing loss in newborns
- Transmitted sexually, via blood, saliva, or by transplanted tissue

Figure 23.19 The Typical U.S. Prevalence of Antibodies Against Epstein-Barr Virus (EB Virus), Cytomegalovirus (CMV), and Toxoplasma Gondii (TOXO) by Age



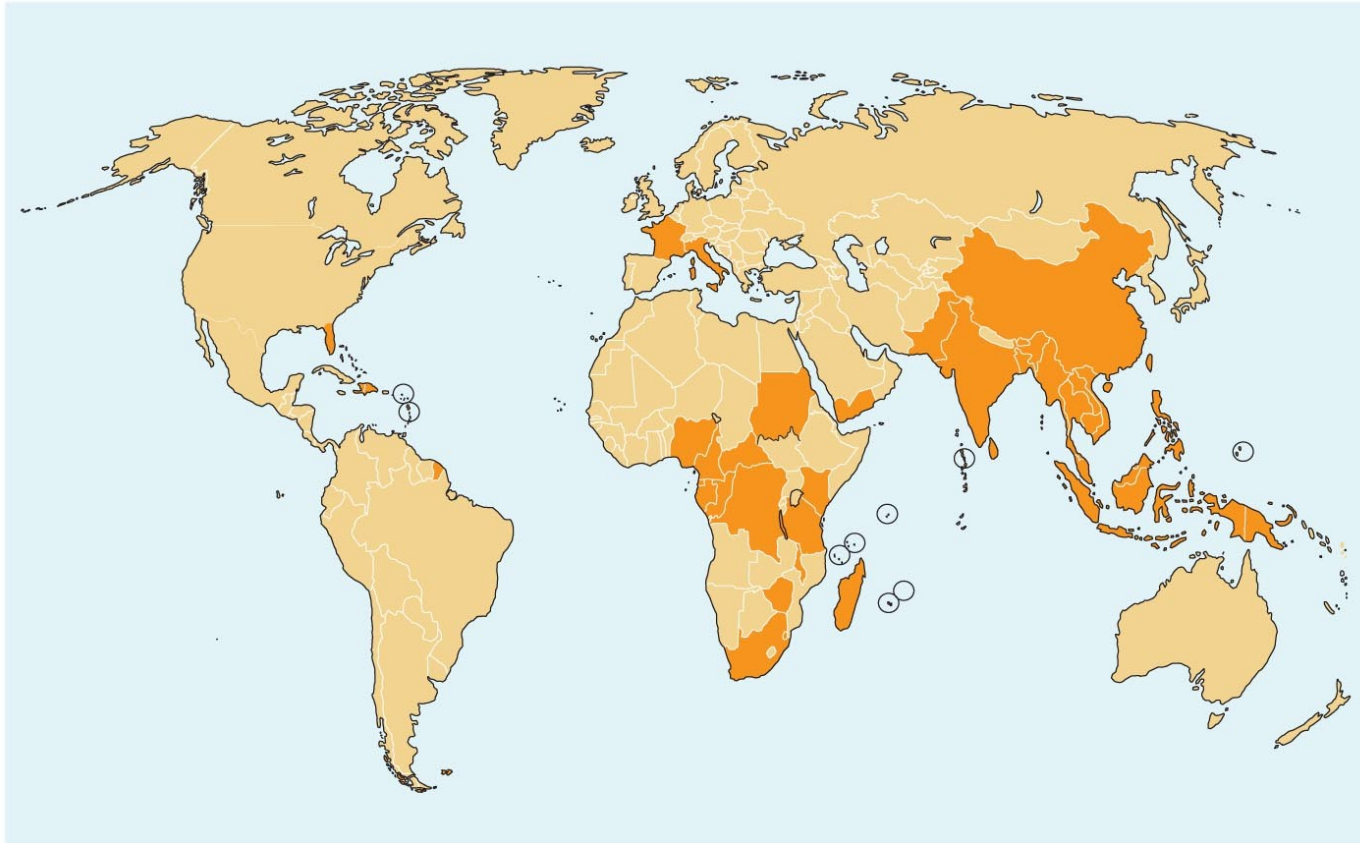
Chikungunya Fever

- Chikungunya virus
 - Related to viruses causing western and eastern equine encephalitis
- Transmitted by **Aedes** mosquitoes
- High fever, severe joint pain, rash, blisters
 - Low death rate
- Introduced to the Western Hemisphere in 2013
 - Half a million cases in the Caribbean
 - Could soon become established in the United States due to the presence of the vector

Big Picture: Climate Change and Disease (1 of 2)

- 2013: first indigenous case of chikungunya fever in the Western Hemisphere
- **Aedes albopictus**
 - Asian tiger mosquito
 - One of two vectors for chikungunya; feeds all day
 - Moving further north in the United States
 - Changing climate has expanded its habitat
 - Could occupy 50% of the United States by 2080

Big Picture pg. 658



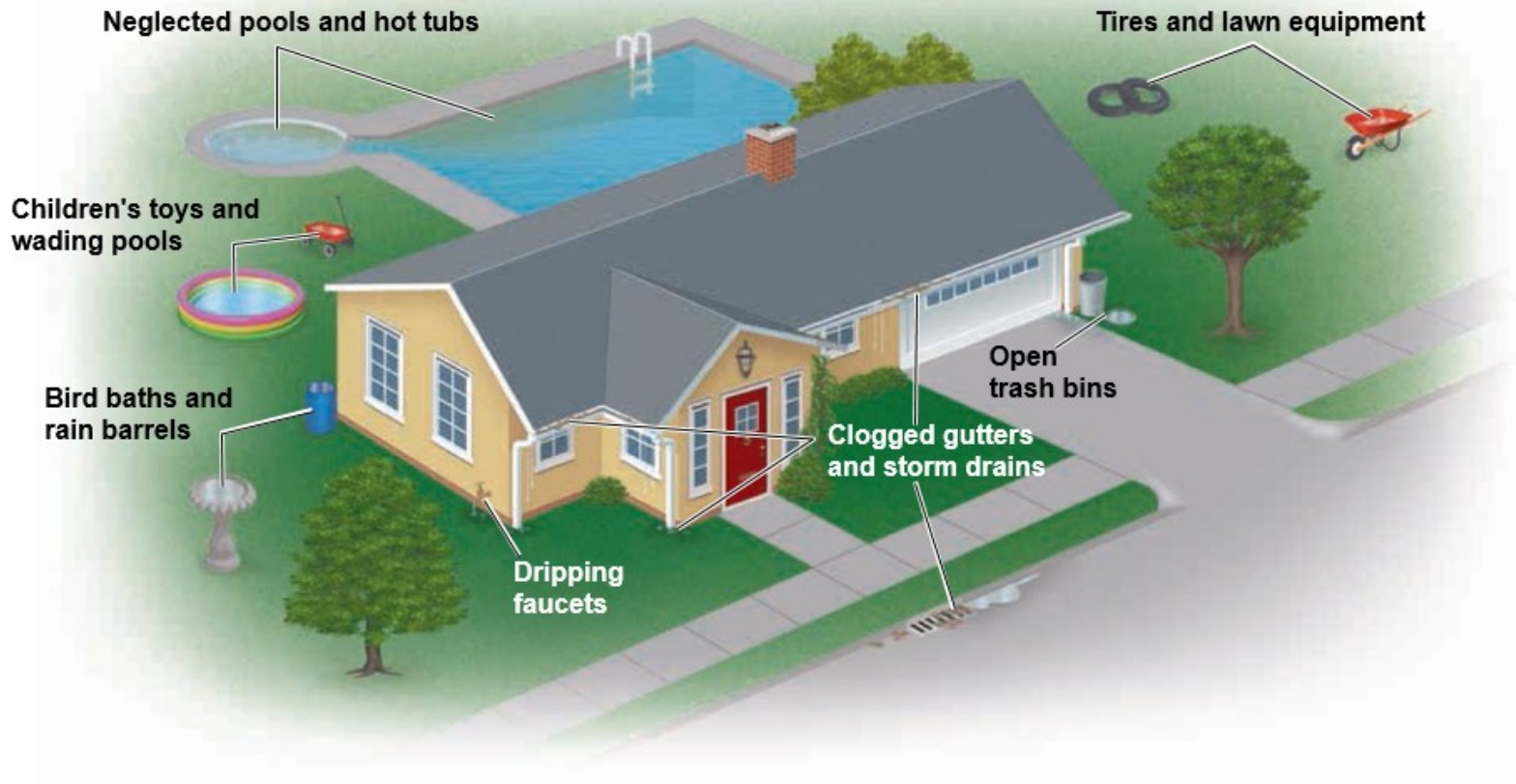
**Countries and territories where chikungunya cases have been reported
(as of August, 2014). Source: CDC.**

Big Picture: Climate Change and Disease (2 of 2)

- Challenges
 - Insecticides do not work well
 - Bed nets are ineffective because Asian tiger mosquitoes feed all day
- Some methods of control
 - Water storage covers
 - Ovitrap
 - Biological control
 - Mosquito dunks

Big Picture pg. 659

Common mosquito habitats around your home



Eliminating sources of standing water is a main line of attack in controlling mosquito populations. The illustration above shows common sources of standing water in homes.

Yellow Fever

- Yellow fever virus is injected into the skin from **Aedes aegypti**
- Fever, chills, headache, nausea, vomiting
- Jaundice due to liver damage
- Endemic in tropical areas
- No treatment; attenuated vaccine available

Dengue and Severe Dengue

- Milder than yellow fever; transmitted by **A. aegypti**
- Endemic to the Caribbean and tropical environments
- Asymptomatic and mild (**dengue**) to severe bleeding and organ impairment (**severe dengue**)
- No animal reservoir
- No vaccine or effective drug treatment

Check Your Understanding-11

Check Your Understanding

- ✓ Why is the mosquito **Aedes albopictus** a special concern to the populations of temperate climates?
23-14

Emerging Viral Hemorrhagic Fevers (1 of 3)

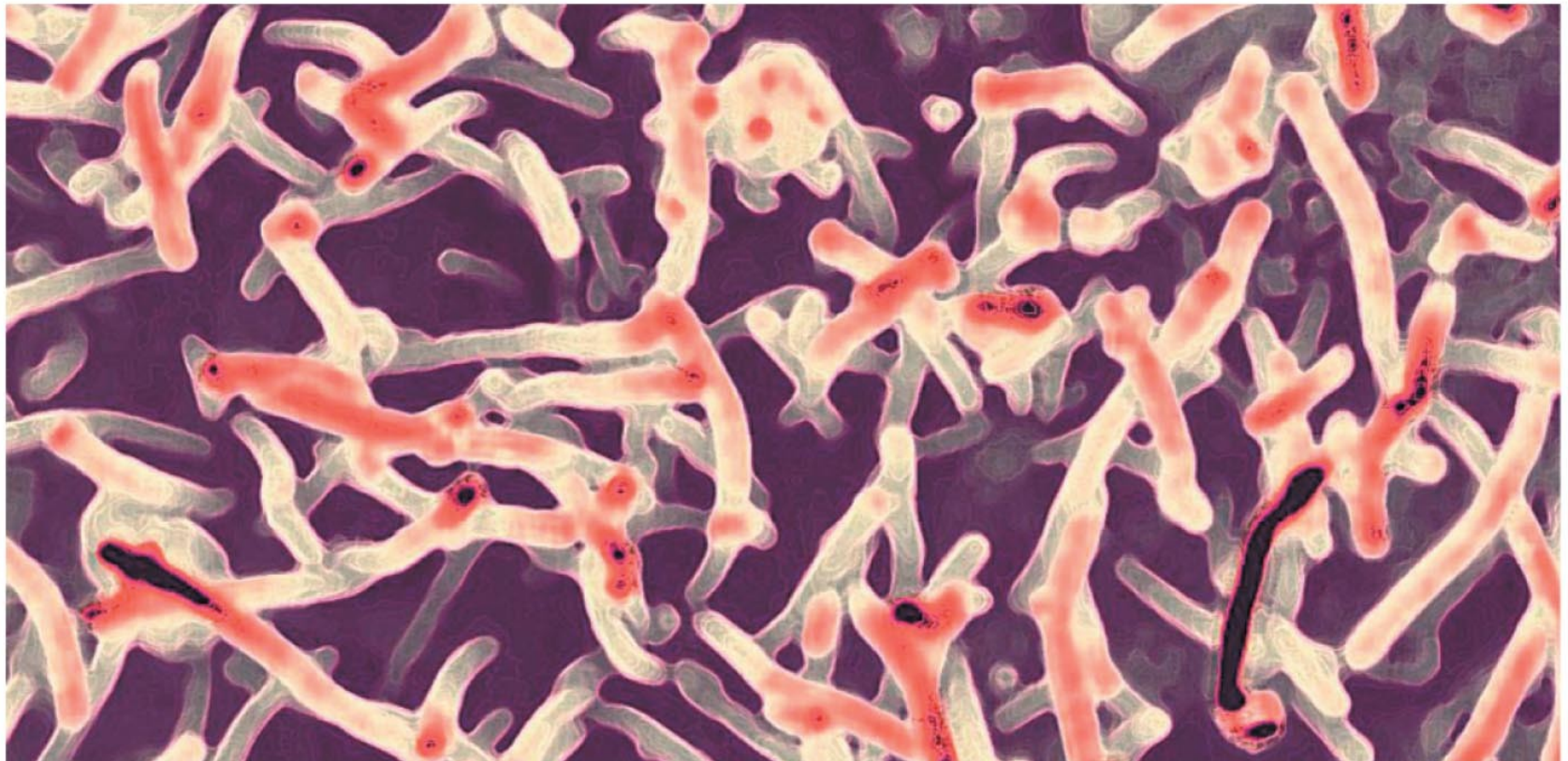
- **Marburg virus (green monkey virus)**
 - Transmitted from African monkeys
 - Headache, high fever, vomiting blood, profuse bleeding internally and externally
- **Lassa fever**
 - **Arenavirus**; found in rodent urine
 - Found in West Africa
 - Similar to **Argentine** and **Bolivian hemorrhagic fevers** (South America) and **Whitewater Arroyo virus** (California)

Emerging Viral Hemorrhagic Fevers (2 of 3)

- **Ebola hemorrhagic fever**

- Caused by the **Ebolavirus**, a filovirus similar to the Marburg virus
- Reservoir is the cave-dwelling fruit bat near the Ebola River in Africa
- Spread by contact with infected body fluids
- Damages blood vessel walls and interferes with coagulation
 - Blood leaks into surrounding tissue
- Mortality rate of 90%

Figure 23.21 Ebola Hemorrhagic Virus



SEM | 250 nm

Emerging Viral Hemorrhagic Fevers (3 of 3)

- **Hantavirus pulmonary syndrome**
 - Caused by the Sin Nombre virus
 - Fatal pulmonary infection; lungs fill with fluids
 - Found in the western United States
 - **Hemorrhagic fever with renal syndrome**
 - Found in Asia and Europe
 - Affects kidney function

Check Your Understanding- 12

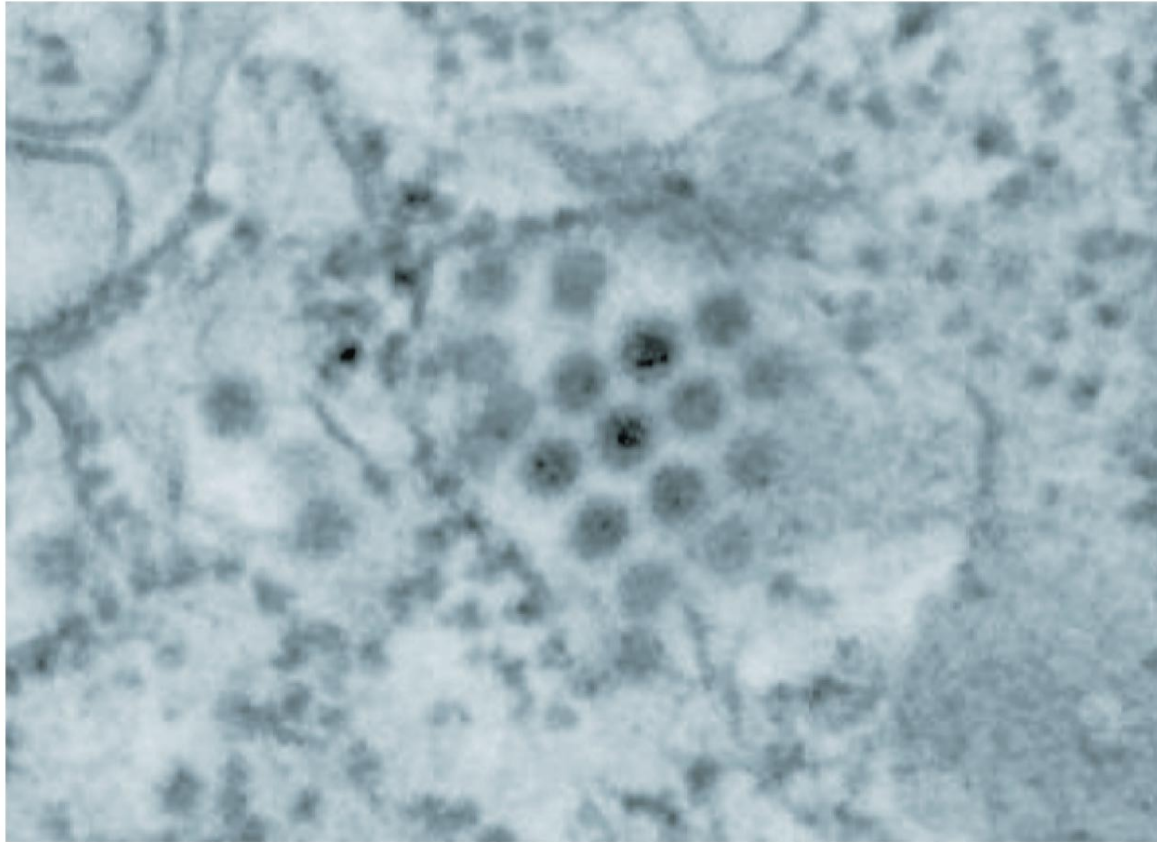
Check Your Understanding

- ✓ Which disease does Ebola hemorrhagic fever more closely resemble, Lassa fever or **Hantavirus** pulmonary syndrome?
23-15

Diseases in Focus: Viral Hemorrhagic Fevers

- What microbe could cause rash and severe joint pain in a 20-year-old woman?

Diseases in Focus 23.4 (1 of 2)



TEM 100 nm

Diseases in Focus 23.4 (2 of 2)

Disease	Pathogen	Portal of Entry	Symptoms	Reservoir	Method of Transmission	Prevention
Yellow Fever	Flavivirus (yellow fever virus)	Skin	Fever, chills, headache; jaundice	Monkeys	Aedes aegypti	Vaccination; mosquito control
Dengue	Flavivirus (dengue virus)	Skin	Fever, muscle and joint pain, rash	Humans	Aedes aegypti; A. albopictus	Mosquito control
Emerging Viral Hemorrhagic Fevers (Marburg, Ebola, Lassa)	Filovirus, arenavirus	Mucous membranes	Profuse bleeding	Possibly fruit bats and other small mammals	contact with blood	None
Hantavirus Pulmonary Syndrome	Bunyavirus (Sin Nombre hantavirus)	Respiratory tract	Pneumonia	Field mice	Inhalation	None

Protozoan Diseases of the Cardiovascular and Lymphatic Systems

Learning Objectives

23-16 Compare and contrast the causative agents, modes of transmission, reservoirs, symptoms, and treatments for Chagas' disease, toxoplasmosis, malaria, leishmaniasis, and babesiosis.

23-17 Discuss the worldwide effects of these diseases on human health.

Chagas' Disease (American Trypanosomiasis)

- Caused by **Trypanosoma cruzi**
 - Flagellated protozoan
 - Reservoir in rodents, opossums, and armadillos
- Vector is the reduviid bug (kissing bug)
 - Defecates trypanosomes into the bite wound of humans
- Chronic form of the disease causes megaesophagus and megacolon
 - Death due to heart damage
- Therapy is difficult due to trypanosome multiplying intracellularly

Figure 23.22 Trypanosoma Cruzi, the Cause of Chagas' Disease (American Trypanosomiasis)



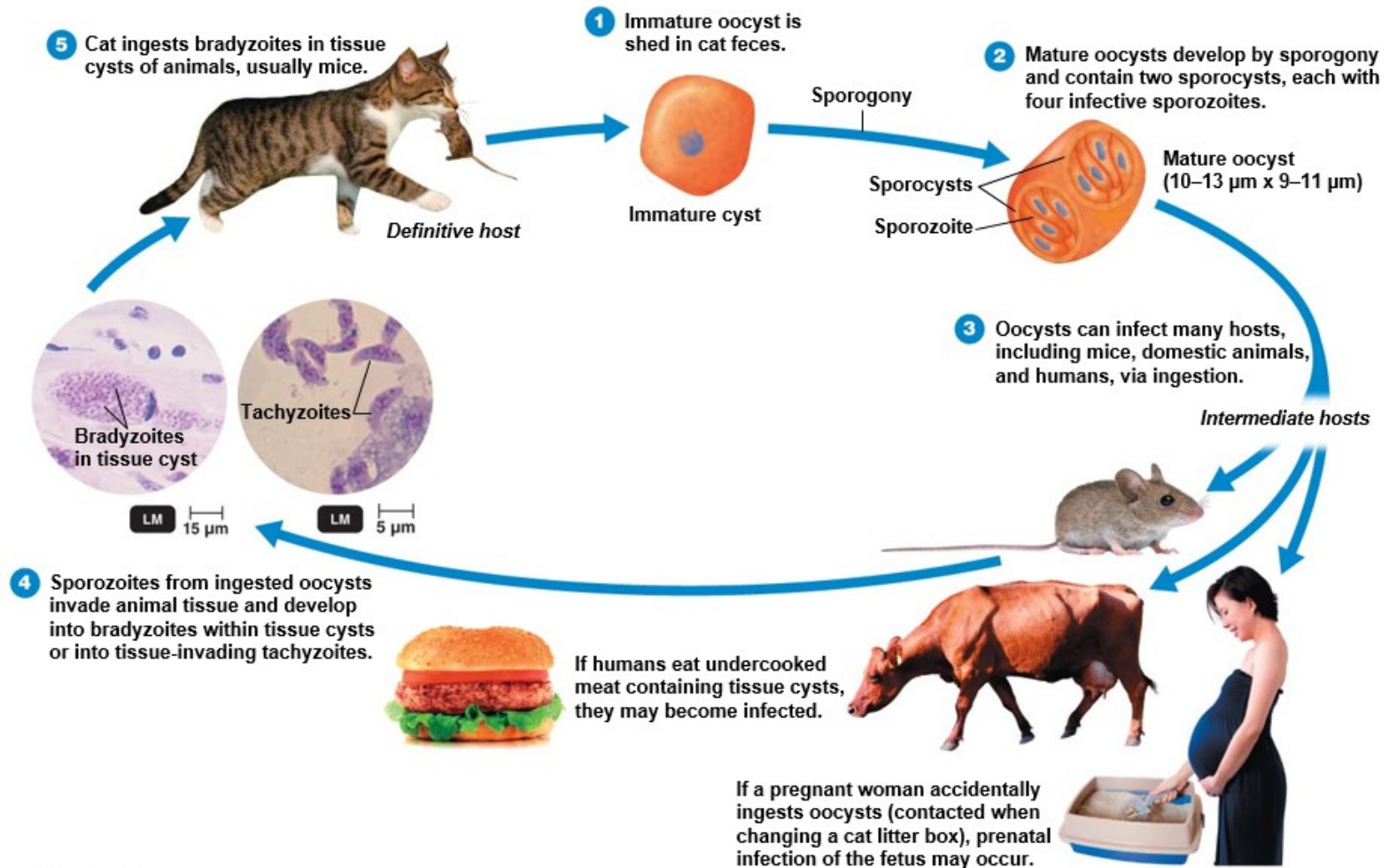
SEM

2.5 μm

Toxoplasmosis

- Caused by **Toxoplasma gondii**
 - Undergoes its sexual phase in cat intestines
 - Oocysts shed in cat feces
- Contact with cat feces or undercooked meat introduces oocysts to the intestines
 - Oocysts form trophozoites that invade cells; may become a chronic infection
- Primary danger is congenital infection
 - Stillbirth
 - Neurological damage

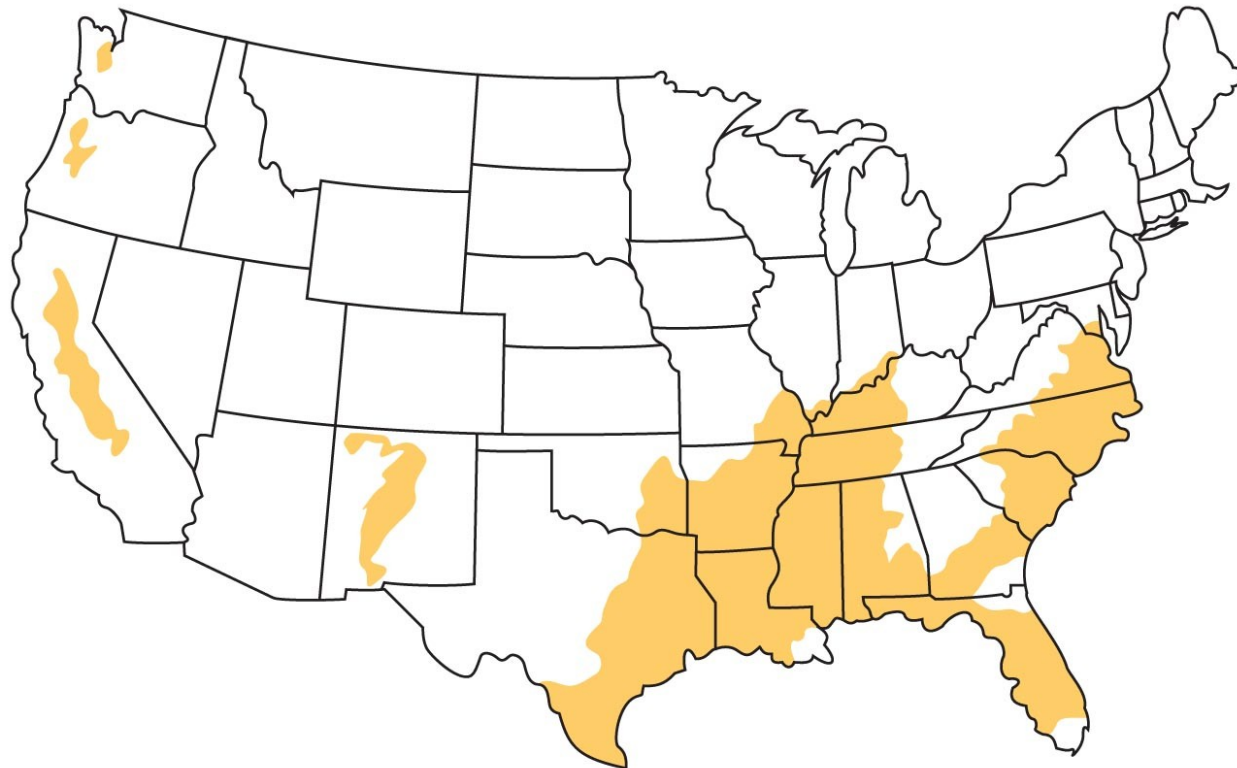
Figure 23.23 The Life Cycle of Toxoplasma Gondii, the Cause of Toxoplasmosis



Malaria (1 of 3)

- Caused by **Plasmodium** parasites
- Transmitted by **Anopheles mosquitoes**
- Affects 300 to 500 million globally; 2 to 4 million deaths annually
- Four major forms:
 - **Plasmodium vivax:** mildest and most prevalent form; dormant in the liver
 - **Plasmodium ovale** and **Plasmodium malariae:** benign; restricted geographically
 - **Plasmodium falciparum:** most deadly; severe anemia; blocks capillaries; affects the kidneys, liver, and brain

Figure 23.24 Malaria in the United States

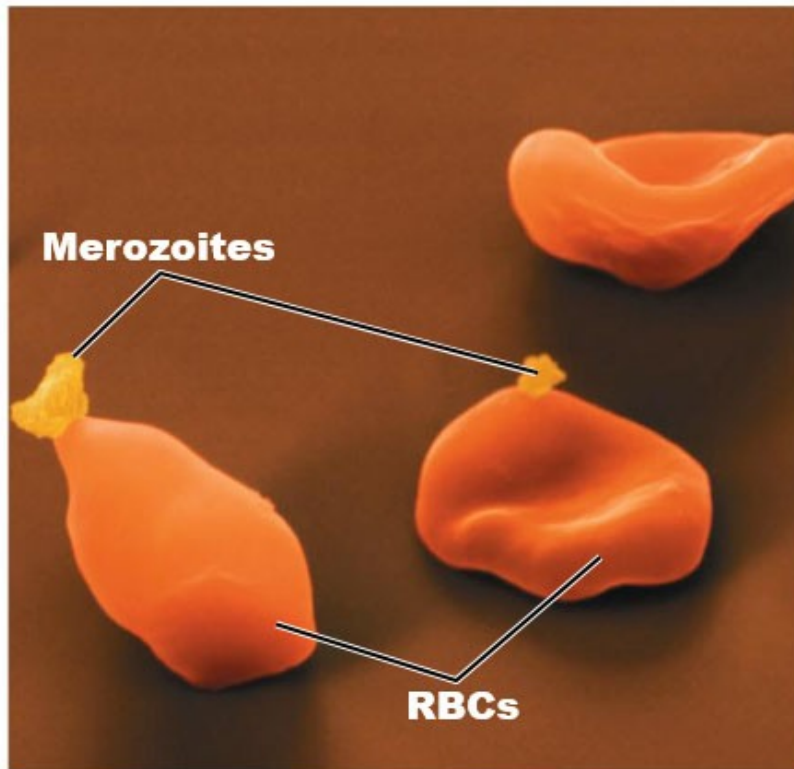


Areas where malaria was endemic as recently as 1912

Malaria (2 of 3)

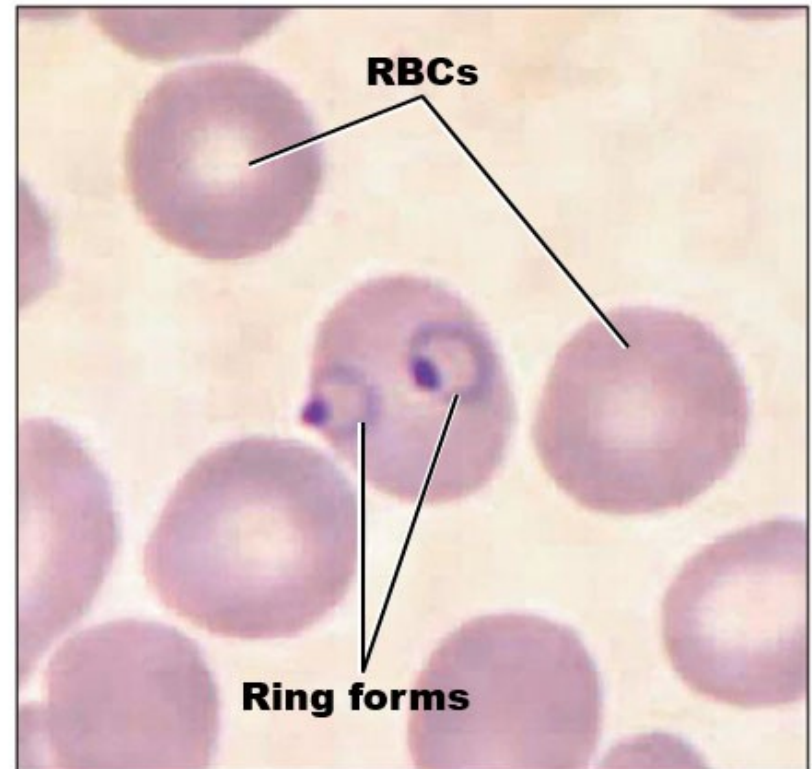
- Mosquito bite transmits sporozoite into the bloodstream
 - Enters the liver cells (which undergo schizogony), resulting in the release of merozoites into the bloodstream
- Merozoites infect RBCs and again undergo schizogony
 - Ruptures the infected RBCs, releasing toxic compounds
 - Causes paroxysms of chills and fever
- Some merozoites develop into gametocytes and are taken up by a mosquito, repeating the cycle

Figure 23.25 Malaria



(a) Merozoites being released from lysed RBCs

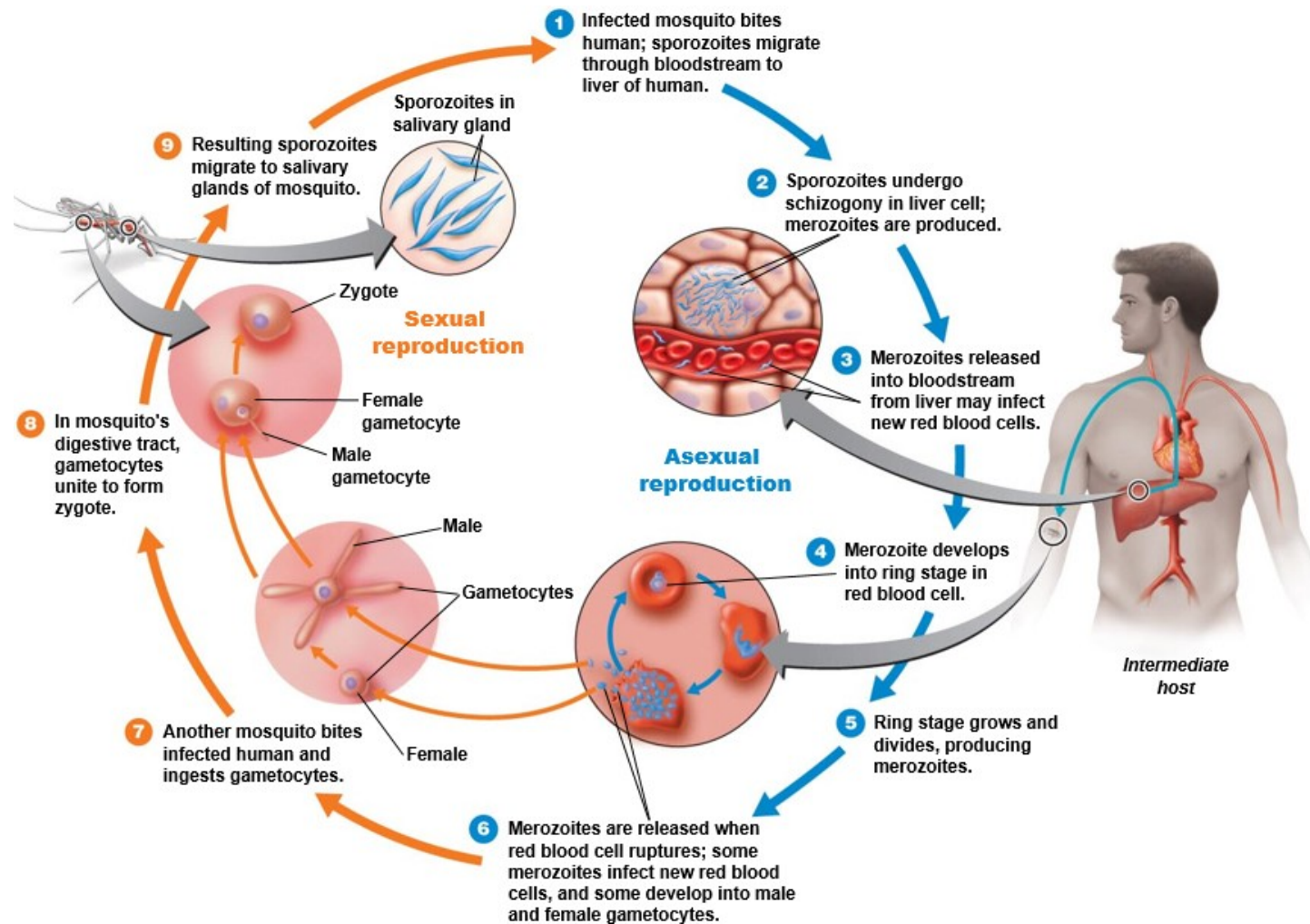
SEM 1.5 μm



(b) Malarial blood smear; note the ring forms.

LM 1.5 μm

Figure 12.20 The Life Cycle of Plasmodium Vivax, the Apicomplexan That Causes Malaria



Malaria (3 of 3)

- Difficult to develop a vaccine
 - **Plasmodium** rapidly mutates and evades an immune response
- Difficult to diagnose without sophisticated equipment
- Prophylaxis
 - Chloroquine; Malarone for chloroquine-resistant areas
- Treatment
 - Artemisinin
- Prevention
 - Bed nets

Leishmaniasis

- Transmitted via female sandflies
 - Promastigote transmitted in saliva from bites
 - Amastigote proliferates in phagocytic cells
- **Leishmania donovani** (visceral leishmaniasis)
 - Invades the internal organs
- **Leishmania tropica** (cutaneous leishmaniasis)
 - Forms a papule that ulcerates and leaves a scar
- **Leishmania braziliensis** (mucocutaneous leishmaniasis)

Figure 23.26 Cutaneous Leishmaniasis



Babesiosis

- Caused by **Babesia microti**
- Carried by **Ixodes** ticks
- Resembles malaria
 - Parasites replicate in RBCs and cause fever, chills, and night sweats
- Treated with atovaquone and azithromycin

Check Your Understanding-13

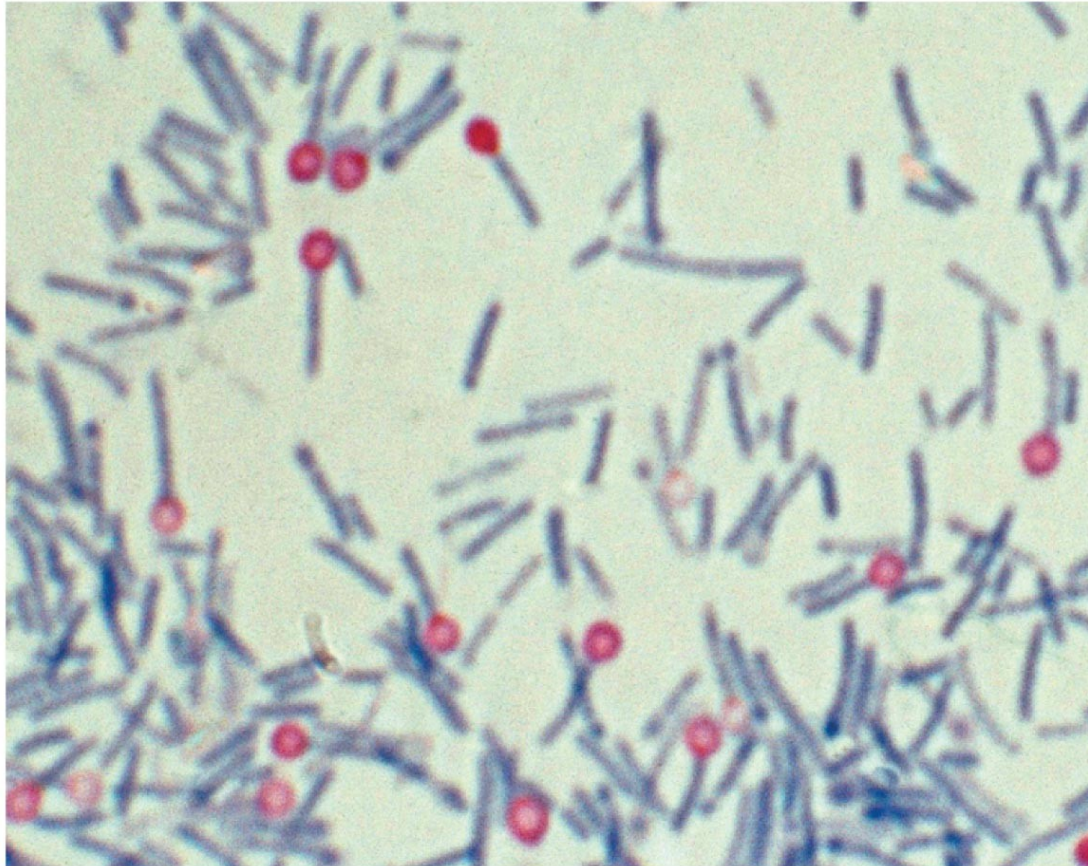
Check Your Understanding

- ✓ What tickborne disease in the United States is sometimes mistaken for malaria when blood smears are inspected?
23-16
- ✓ Eliminating which of these diseases, malaria or Chagas' disease, would have the greater effect on the well-being of the population of Africa?
23-17

Diseases in Focus: Infections Transmitted by Soil or Water

- A 65-year-old man with poor circulation in his legs develops an infection following injury to a toe.
Dead tissue further reduces circulation, requiring amputation of two toes.
- What infection could cause these symptoms?

Diseases in Focus 23.5 (1 of 2)



LM

2.5 μm

Diseases in Focus 23.5 (2 of 2)

Disease	Pathogen	Symptoms	Reservoir	Method of Transmission	Treatment
BACTERIAL DISEASE					
Gangrene	Gangrene Clostridium perfringens	Tissue death at infection site	Soil	Puncture wound	Surgical removal of necrotic tissue
HELMINTHIC DISEASE					
Schistosomiasis	Schistosoma spp.	Inflammation and tissue damage at site of granulomas (e.g., liver, lungs, bladder)	Definitive host; humans	Cercariae penetrate skin	Praziquantel ; oxamniquine Prevention: sanitation; elimination of host snail

Helminthic Disease of the Cardiovascular and Lymphatic Systems

Learning Objective

23-18 Diagram the life cycle of **Schistosoma**, and show where the cycle can be interrupted to prevent human disease.

Schistosomiasis

- Caused by small flukes called **Schistosoma**
 - Feces carrying eggs get into the water supply
 - Snails serve as the intermediate host
 - Cercariae released from the snail penetrate the skin of humans
 - Eggs shed by adult schistosomes in the host lodge in tissues, forming **granulomas**
- **Schistosoma haematobium**: urinary schistosomiasis
- **Schistosoma japonicum**: intestinal inflammation; found in Asia
- **Schistosoma mansoni**: intestinal inflammation; found in South America



Figure 23.27 Schistosomiasis

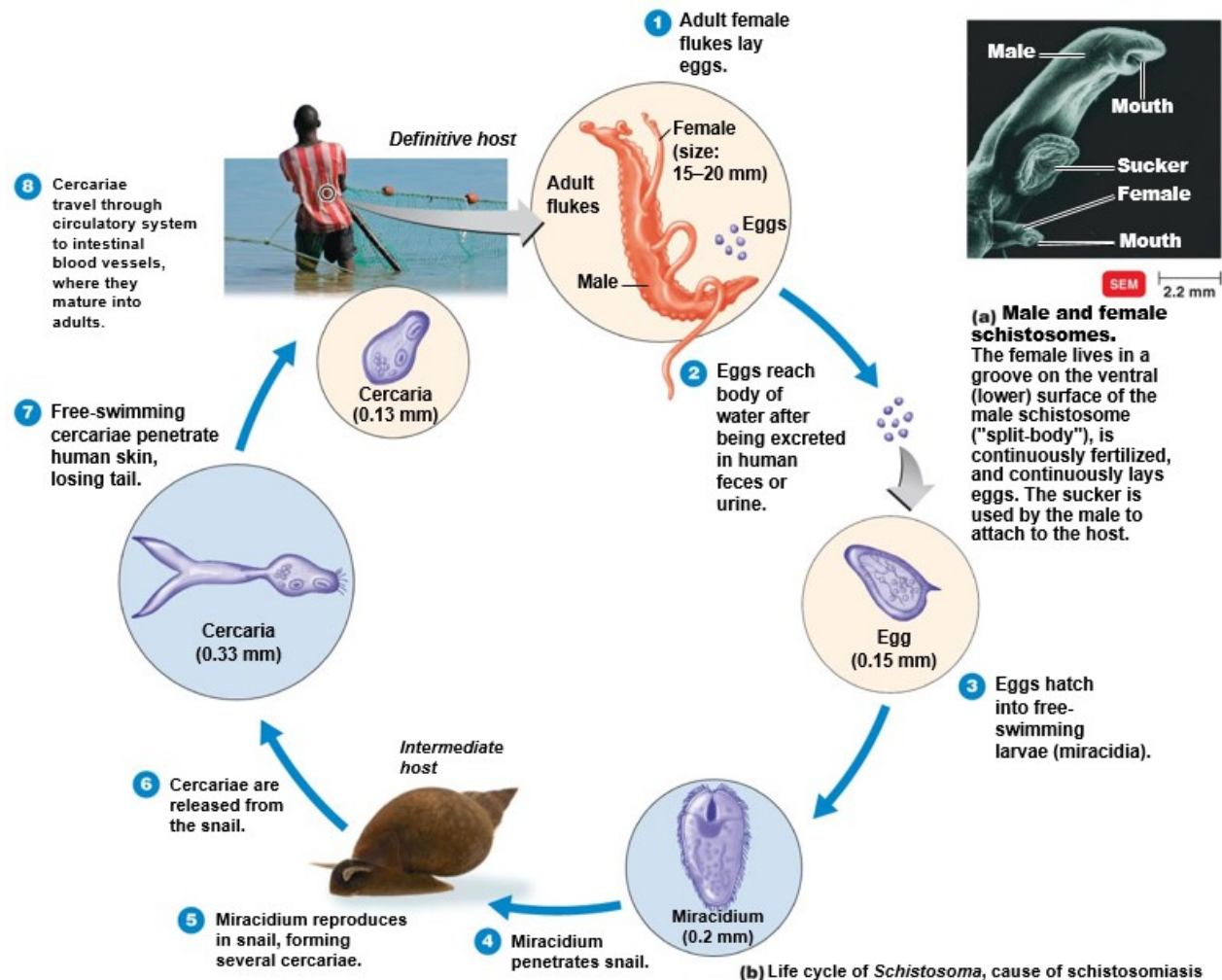


Figure 23.28 A Granuloma from a Patient with Schistosomes



LM

0.1 mm

Check Your Understanding-14

Check Your Understanding

- ✓ What freshwater creature is essential to the life cycle of the pathogen causing schistosomiasis?
23-18

Disease of Unknown Etiology

Learning Objective

23-19 Recognize the clinical features of Kawasaki Syndrome.

Kawasaki Syndrome

- Acute febrile illness of unknown etiology
- Most often affects younger children
- High fever, widespread rash, hand and feet swelling, swollen lymph glands
- Treated with aspirin
- Possible immunological cause

Check Your Understanding-15

Check Your Understanding

- ✓ What diseases of the cardiovascular and lymphatic systems need to be ruled out before a clinician can conclude that a patient has Kawasaki syndrome?
23-19